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RANDI 3.1 User's Guide

J. Ernest Breeding
Lisa A. Pflug

Ocean Acoustics Branch
Center for Environmental Acoustics

Marshall Bradley
Melanie Hebert
Michael Wooten

Planning Systems Incorporated

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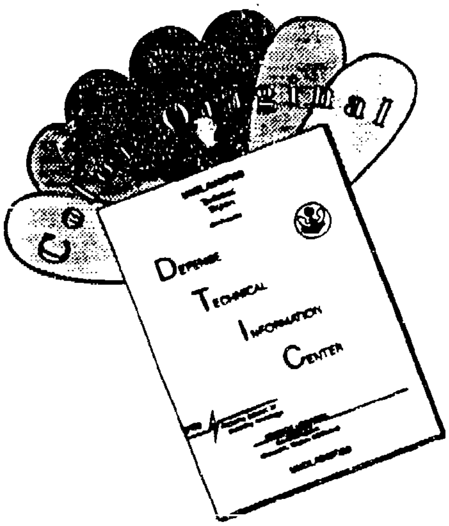
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A user's guide is presented for the Research Ambient Noise Directionality (RANDI) model version 3.1. The RANDI 3.1 model can be used to predict ambient acoustical noise levels and directionalities at low to midfrequencies for shallow- and deep-water environments. Ambient noise due to shipping, wind, flow noise, and system noise are considered. Shipping noise can be calculated for highly variable environments and is done using either a finite element or split-step parabolic equation. Local wind noise is computed based on the range-xindependent theory of Kuperman-Ingenito including both discrete (normal modes) and continuous spectra. Navy-standard and historical databases are used to describe the environment. The noise model particulars, inputs, and outputs are described and illustrated for an example model run.

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TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 MODEL SPECIFICATIONS 3
2.1 Hardware/Software Requirements 3
2.2 Installation 3
2.3 Directory Hierarchy 3

3.0 DATABASES 5

4.0 INPUT DESCRIPTION 9
4.1 Run Frequency 9
4.2 Location Particulars 9
4.3 Array Particulars 10
4.4 Shipping Noise 10
4.5 Shipping Data 11
4.6 Beamforming 12
4.7 Dead Reckoning 12
4.8 Wind Noise 12
4.9 Flow Noise 13
4.10 System Noise 13
4.11 Tow Ship Noise 14
4.12 Environmental Data 14
4.13 Propagation 15
4.14 Shipping Input File 16
4.15 Volumetric Array Input File 17
4.16 Wind Input File 18

5.0 MODEL EXECUTION 19
5.1 Command Format 19
5.2 Model Flow Diagram 19

6.0 OUTPUT DESCRIPTION 19
6.1 Noise Field, Array Response, and Horizontal Directionality File 20
6.2 Shipping Information File 21
6.3 Wind Model File 21
6.4 Complex Pressures at Each Dead Reckoning Files 21
6.5 Processed Ships File 21
6.6 Error File 21
6.7 Environment File 21
6.8 Transmission Loss / Signal Level Curve Files 22
6.9 Transmission Loss / Signal Level Field Files 22
6.10 Omnilevels at Hydrophones File 22
6.11 Time File 22
6.12 Flow Noise File 22
6.13 Ship Noise File 22
6.14 System Noise File 22
6.15 Wind Noise File 22
6.16 Pressure File 23
6.17 Cumulative Pressure File 23
6.18 Vertical Directionality File 23
6.19 Volumetric Array Beam Noise File 23

7.0 SUPPORT SOFTWARE AND GRAPHICS DESCRIPTIONS 24
7.1 Bathymetry Extraction Program 24
7.2 Geographic View of Bathymetry Display Program 25
7.3 Geographic View of Bathymetry with Radial Display Program 27
7.4 Geographic View of Discrete Shipping Display Program 29
7.5 Geographic View of Shipping Density Display Program 31
7.6 Array Heading Surface Display Program 33
7.7 Environmental Display Program 34
7.8 Transmission Loss / Signal Level Display 36
7.9 Transmission Loss / Signal Level Field Plot Display 37
7.10 Array Response, Noise Field, and Horizontal Directionality Display Program 39
7.11 Omni Noise Level Display Program 41
7.12 3-D Ambient Noise Field Display 42
7.13 Vertical Directionality Calculation Programs 44
7.14 Ambient Noise 3-D Directionality Display 45
7.15 AACDF Display Program 47
7.16 Volumetric Array Beam Surface Display 48
7.17 Summary of RANDI 3.1 Graphics Routines 50

8.0 RANDI 3.1 EXAMPLE RUN DESCRIPTION 52

ACKNOWLEDGMENTS 78

REFERENCES 79

LIST OF TABLES

Table 2.1 Disk space required for RANDI 3.1 3

Table 3.1 ETOPO5 Database Description 5
Table 3.2 DBDBC Database Description 5
Table 3.3 HOP GDEM Database Description 6
Table 3.4 SWSS Database Description 6
Table 3.5 CBLUG Database Description 7
Table 3.6 LFBL Database Description 7
Table 3.7 Historical Windspeed Database Description 8
Table 3.8 HITS Database Description 8

Table 6.1 RANDI 3.1 output file (*main.out*) format 20

Table 7.1 Summary of RANDI 3.1 Graphics Routine 50

LIST OF FIGURES

Figure 1
Example input file.......... 53
Figure 2
Example shipping input file.......... 56
Figure 3
Example processed shipping output file.......... 57
Figure 4
Example beam, array response, noise output file.......... 58
Figure 5
Example geographic view of bathymetry plot.......... 61
Figure 6
Example geographic view of bathymetry and shipping plot.......... 62
Figure 7
Example geographic view of discrete shipping plot.......... 63
Figure 8
Example geographic view of shipping lanes plot.......... 64
Figure 9
Example array heading surface plot.......... 65
Figure 10
Example environment plot.......... 66
Figure 11
Example transmission loss curve plot.......... 67
Figure 12
Example transmission loss field plot.......... 68
Figure 13
Example beam noise plot.......... 69
Figure 14
Example shipping noise field spike plot.......... 70
Figure 15
Example smoothed shipping noise field plot.......... 71
Figure 16
Example omnilevel vs hydrophone curve plot.......... 72
Figure 17
Example 3-d ambient noise field plot.......... 73
Figure 18
Example ambient noise 3-d directionality plot.......... 74
Figure 19
Example azimuthal anisotropic cumulative distribution function plot.......... 75
Figure 20
Example volumetric array input file.......... 76
Figure 21
Example volumetric array beam surface plot.......... 77

1.0 INTRODUCTION

The purpose of this report is to present a users guide for the Research Ambient Noise Directionality noise model version 3.1, hereafter referred to as RANDI 3.1.

The objective of the RANDI 3.1 model is to predict the response of low-mid frequency sonar receivers to the ocean acoustic noise field in locations with highly variable surrounding bathymetry and range dependent sound speed structure. Such environments are typical of the complex oceanographic areas found in shallow water and coastal areas, although the RANDI 3.1 model can be applied equally well in deep water areas. RANDI 3.1 achieves its objective by combining state of the art acoustic propagation models, computational algorithms, and geographic environmental databases into a single product.

RANDI 3.1 was inspired by the Research Ambient Noise Directionality II (RANDI II) model developed at SACLANTCEN by M. Hamson and R. Wagstaff (1). RANDI II is an ambient noise model that predicts noise levels and directionalities for user-specified environmental and shipping conditions using adiabatic mode theory to propagate energy from individual ships to a receiver array. The array response for each ship is calculated by summing the complex pressure due to individual modes at each hydrophone in the receiver array, followed by either coherent or incoherent summation across modes. In RANDI II, shallow water wind noise is estimated using a wave theory model developed by Kuperman and Ingenito (2) for a cross spectral density matrix between all hydrophones in a receiver array.

RANDI II suffered from computational limitations centered around the use of normal mode theory making it difficult to use the model in deep water where the number of propagating modes is large or in areas with rapid oceanographic or bathymetric changes. RANDI 3.1 overcomes these difficulties by using parabolic equation (PE) propagation loss models to propagate energy from individual ships to the receiver array. Currently, RANDI 3.1 incorporates two parabolic equation models: Finite Element PE (FEPE) and the Navy Standard PE, also referred to as the Split-Step PE (SSPE). The SSPE model (3) is a solution to the parabolic equation that involves a marching type Fourier transform solution with a relatively wide-angle capability (up to 40 degrees half-beamwidth). The FEPE model (4,5) is a higher-order PE model based on a Pade series expansion of the depth-dependence part of the parabolic equation. FEPE was developed in an effort to handle propagation angles approaching 90 degrees. The use of PE propagation codes in RANDI 3.1 greatly extends the frequency range and the range of oceanographic conditions for which valid noise predictions can be made.

RANDI 3.1 computes the shipping complex pressure by one of three parabolic equation transmission loss processing methods. These are the brute force method, the radial accumulation method, and the high resolution radial accumulation method. The brute force method executes the propagation model, either FEPE or SSPE, from each ship to the receiver. The radial accumulation method discretizes the azimuthal direction into radials and executes the propagation model from the maximum ship range of each radial to the receiver, accumulating ships as it marches inward. The high resolution radial accumulation method, in addition to executing the radial accumulation method, computes the complex pressures at each hydrophone for each ship instead of for each radial. The radial accumulation method and the high resolution radial method are computed using only the FEPE model.

RANDI 3.1 is fully interfaced to supporting geographical environmental databases of bathymetry, sound speed, bottom properties, shipping, and windspeed. The model extracts environmental information from Navy standard databases including ETOPO5 and DBDBC for bathymetry, HOP GDEM and SWSS for sound speed profiles, and LFBL and Consolidated BLUG for bottom parameters. Shipping information is obtained from the HITS 3.1 and HITS 3.0

databases, and windspeed from the Historical Windspeed database. RANDI 3.1 also allows for a variety of array types, beamforming options and output displays.

The specifications for running the RANDI 3.1 noise model are described in Section 2. A description of the supporting geographical environmental databases is presented in Section 3. Section 4 contains an explanation of the input information required to run the model. The way in which the model is executed is described in Section 5. The most important output files are explained in Section 6. The plots that can be produced by the model's supporting graphics routines are explained in Section 7. Finally, in order to illustrate the various inputs and outputs of the noise model, a sample run is presented in Section 8.

2.0 MODEL SPECIFICATIONS

2.1 Hardware/Software Requirements

The RANDI 3.1 model runs on a SUN SparcStation 2 or SparcStation 330, and operates with the SUN (Stanford University Network) Operating System Version 4.1.3. The disk space needed for the RANDI 3.1 model is summarized in Table 2.1.

Table 2.1 Disk space required for RANDI 3.1

Module	Size (MegaBytes)
Source/object code	8.8
Executable code	46.8
Databases	195.9
TOTAL	251.5

The model code is written in FORTRAN and compiled and linked using SUN FORTRAN version 1.4. The graphics programs are written in FORTRAN and utilize SUN-GKS (Graphic Kernel System) version 3.0. A "popup menu" routine is written in C. Output is displayed on the SUN monitor, and hardcopies can be obtained by using postscript files created by TranScript version 2.1, or by "screendumping" to a raster file. The model needs approximately 93 megabytes of memory to run.

2.2 Installation

Installing the RANDI 3.1 model with the appropriate databases is described in detail in documentation delivered with the tapes. The model and databases are delivered on data cartridge or exabyte tapes in tar format. The user extracts the files from the tapes to the computer and uses a "Makeall" to compile and link the source code.

2.3 Directory Hierarchy

The RANDI 3.1 directories are located under the user selected directory referred to as *pathname*. Below that directory are the various directories needed for RANDI 3.1 compilation and execution. Note: the directories listed below are for the source code only, the databases will be under separate directories, but will also be below *pathname* (see separate installation documentation).

pathname/source - the main directory containing source code for each module of the model.
pathname/source/env_sw - contains the source code for the environmental extraction programs.
pathname/source/randi - contains the main source code for the RANDI 3.1 model, including the code for omni noise level calculation, wind input generation, and shipping extraction routines.
pathname/source/sspe - contains the source code for the Navy Standard PE model.
pathname/source/vert - contains the source code to calculate vertical directionality.
pathname/source/wind - the main directory for the wind model.
pathname/source/wind/main - contains the source code for the wind model layer matrix program.
pathname/source/wind/ffs - contains the source code for the wind model fast field program.
pathname/source/wind/driver - contains the source code for the wind model normal mode program.
pathname/source/plot - the main directory containing source code for each of the plotting routines.
pathname/source/plot/aacdf - contains the source code for the azimuthal anisotropic cumulative distribution plot.
pathname/source/plot/ahs - contains the source code for the array heading surface display.
pathname/source/plot/bathygcp - contains the source code for the bathmetry with shipping and radial great circle paths plot.

pathname/source/plot/bathyplt - contains the source code for the bathymetry extraction and display.
pathname/source/plot/dir - contains the source code for the directionality plot.
pathname/source/plot/env - contains the source code for the environmental plot.
pathname/source/plot/fld - contains the source code for the transmission loss / signal level field plot.
pathname/source/plot/hits - contains the source code for the shipping display plot.
pathname/source/plot/main - contains the source code for the array response, shipping noise, horizontal directionality plotting package.
pathname/source/plot/omn - contains the source code for the omni noise level plot.
pathname/source/plot/shipden - contains the source code for the shipping densities plot.
pathname/source/plot/tl - contains the source code for the transmission loss / signal level line plot.
pathname/source/plot/vert - contains the source code for the vertical directionality plot.
pathname/source/plot/volume - contains the source code for the volumetric array beam surface plot.
pathname/run - the main directory for model runs. It is suggested that each run have its own directory under this main directory.
pathname/exe - contains all executable code pertaining to the RANDI 3.1 model. All make files existing in the source directories will move the executable programs to this directory.

3.0 DATABASES

RANDI 3.1 is supported by environmental databases containing bathymetry (ETOPO5 and DBDBC), sound speed (HOP GDEM and SWSS), bottom loss (CBLUG and LFBL), windspeed (HWS), and shipping (HITS) information. The geographic coverage of these databases is as follows:

- The Atlantic basin covers latitude from 0 to 76N, longitude from 98W to 90E.
- The Pacific basin covers latitude from 0 to 75N, longitude from 99E to77W.
- The Indian basin covers latitude from 40S to 30N, longitude from 20E to 150E.
- The Mediterranean basin covers latitude from 30N to 50N, longitude from 6W to 42E.

Table 3.1 ETOPO5 Database Description

ETOPO5 - DIGITAL BATHYMETRY DATABASE	
Description:	The ETOPO5 Bathymetry Database is a subset of the NAVOCEANO DBDB5 Digital Bathymetry Database providing ocean depths which are measured acoustically, referenced by 1500 m/s velocity.
Data Type:	Bathymetry.
Usage:	The ETOPO5 Database is used to provide unclassified ocean depths for ocean acoustic modeling applications.
Coverage:	All four basins.
Resolution:	1/12 degree grid
Classification:	Unclassified

Table 3.2 DBDBC Database Description

DBDBC - CONFIDENTIAL DIGITAL BATHYMETRY DATABASE	
Description:	The NAVOCEANO Confidential Digital Bathymetry Database provides ocean depths which are measured acoustically, referenced by 1500 m/s velocity.
Data Type:	Bathymetry.
Usage:	The DBDBC Database, used in virtually all ocean acoustic modeling applications, provides ocean depths.
Coverage:	All four basins.
Resolution:	1/12 degree grid
Classification:	Confidential

Table 3.3 HOP GDEM Database Description

HOP GDEM - Historical Ocean Profile Generalized Digital Environmental Model	
Description:	The NAVOCEANO Historical Ocean Profile Generalized Digital Environmental Model Data Base is a provinced version of the original NAVOCEANO GDEM database and describes the seasonal depth and sound speed profiles.
Data Type:	Depth, sound speed profiles.
Usage:	The HOP GDEM profiles are used in environmental predictions models and in testing acoustic models.
Coverage:	All four basins.
Resolution:	Seasonal 1/2 degree grid
Classification:	Unclassified

Table 3.4 SWSS Database Description

SWSS - SHALLOW WATER SOUND SPEED DATABASE	
Description:	The Shallow Water Sound Speed Database provides seasonal temperature and salinity profiles at standard depths for areas with bathymetries between 50 and 500 meters.
Data Type:	Temperature, salinity profiles.
Usage:	Shallow Water profiles are used in environmental prediction models and in testing acoustic models. The Shallow Water Sound Speed Database is not an approved Navy Standard database as of the writing of this document, but is the only broad coverage source of shallow water sound speed data known to the authors.
Coverage:	Most of the shallow regions of the four basins.
Resolution:	1/12 degree grid
Classification:	Unclassified

Table 3.5 CBLUG Database Description

CBLUG - CONSOLIDATED BLUG DATABASE	
Description:	The Consolidated BLUG Database provides an unclassified version of the geoacoustic parameters which describe the sound interaction with the seafloor, the density, the sound speed, and the attenuation of the fluid layer, and also the surface layer thickness and density.
Data Type:	Geoacoustic parameters.
Usage:	The Consolidated BLUG Database provides geoacoustic parameters that can be converted into geoacoustic bottom descriptions, which can then be incorporated into transmission loss models on machines that are not authorized for classified data processing
Coverage:	There is no Consolidated BLUG data for the Mediterranean basin. There is only coverage in the deep areas for the other three basins.
Resolution:	1/12 degree grid
Classification:	Unclassified

Table 3.6 LFBL Database Description

LFBL - LOW FREQUENCY BOTTOM LOSS DATABASE	
Description:	The NAVOCEANO Low Frequency Bottom Loss Database describes the acoustic properties of the ocean sediment and sediment thickness at low frequencies (50 to 1600 Hz). The data base geographically divides the ocean into areas that are homogeneous in sediment and in composition type. These provinces point to the geoacoustic parameters defined in the geoacoustic data. The geoacoustic parameters provide a bottom loss upgrade (blug) geoacoustic profile. The geoacoustic parameters describe the sound interaction with the seafloor, the density, the sound speed, and the attenuation of the fluid layer, and also the surface layer thickness and density and the substrate reflectivity.
Data Type:	Low frequency bottom loss, geoacoustic parameters.
Usage:	The BLUG data and the geoacoustic parameters can be converted into bottom loss versus grazing angle or into geoacoustic bottom description incorporated into transmission loss models.
Coverage:	All four basins.
Resolution:	1/6 degree grid
Classification:	Confidential

Table 3.7 Historical Windspeed Database Description

HISTORICAL WINDSPEED DATABASE	
Description:	The Historical Windspeed Database provides monthly mean windspeeds with standard deviations that can be used to calculate a windspeed in knots
Data Type:	Monthly mean windspeeds with standard deviations.
Usage:	The Historical Windspeed Database is used in providing windspeed for environmental predictions and testing acoustic models.
Coverage:	All four basins.
Resolution:	1 degree grid
Classification:	Unclassified

Table 3.8 HITS Database Description

HITS - Historical Interim Temporal Shipping	
Description:	The Historical Interim Temporal Shipping Database provides the ship density for each one degree square. The database was updated from HITS 3.0 to HITS 3.1 in 1993 by Planning Systems, Inc.
Data Type:	Ship densities for merchant ships, tankers, large tankers, and super tankers. NOTE: fishing vessels are not included in the HITS version 3.1 database, so they are provided by HITS version 3.0.
Usage:	The HITS databases are used for ambient noise predictions.
Coverage:	All four basins.
Resolution:	1 degree grid merchant ships, tankers, large tankers, super tankers - monthly, seasonal, annual fishing vessels - winter/summer, annual
Classification:	Unclassified

4.0 INPUT DESCRIPTION

The RANDI 3.1 model requires an input file containing parameters which are described in Section 4.1 - 4.13. A set of default input parameters are defined at run time. The default parameters can then be modified using a menu-driven interface or overridden by providing the name of an existing input file. In addition, the menu-driven interface provides the user with guidelines for choosing input parameters. Figure 1 shows an example input file. The input descriptions for this file have the following format:

Variable Description of variable.
{units of variable}
[limits of variable]

The program will terminate if the input variable is not within the specified limits.

Additional input files include the optional shipping input file (Section 4.14), an input file containing array coordinates required for the volumetric array option (Section 4.15), and the optional wind cross correlation matrix file (Section 4.16).

4.1 Run Frequency

Frequency Frequency. Run time can be long for higher frequencies.
{Hz}
[0,10000]

4.2 Location Particulars

Siteid Site identification used on the output displays.
{none}
[character*15]

Latitude Receiver array (center hydrophone) latitude position.
{deg, + North, -South}
[0,85]

Longitude Receiver array (center hydrophone) longitude position.
{deg, + East, -West}
[-180,180]

Season Flag to indicate season for environmental extractions.
For Atlantic, Pacific, and Mediterranean regions:
1 = Winter (Jan - Mar)
2 = Spring (Apr - Jun)
3 = Summer (Jul - Sep)
4 = Fall (Oct - Dec)
For Indian Ocean region:
1 = Winter (Oct - Feb)
2 = Spring (Mar - May)
3 = Summer (Jun - Jul)
4 = Fall (Aug - Sep)
{none}
[1, 2, 3, or 4]

Sound speed Reference sound speed, generally the sound speed at the array center depth.

{m/s}
[1200, 1800]

4.3 Array Particulars

Tilt angle — Array tilt angle from horizontal. Only vertical (90 deg), and horizontal (0 deg) arrays are allowed if wind noise is calculated.
{deg}
[0 to 90]

Number hydrophones — Number of hydrophones (NHYD) in receiver array. If using an FFT beamformer, the number of hydrophones must equal the number of beams.
{none}
[1, 256]
[1,100] for wind model runs with a vertical array

Hydrophone Spacing — Hydrophone spacing. For an FFT beamformer, if the spacing is less than the wavelength divided by 2, there will be virtual beams. However, RANDI 3.1 will only output the real beams.
{m}
[dependent on frequency and bathymetry of area]

Receiver depth — Array center depth. Number must be chosen so that none of the hydrophones are below the bottom.
{m}
[dependent on array tilt and bathymetry of area]

Reference phone — Reference hydrophone number to use for computation of noise distribution. The first hydrophone is the deepest and the NHYDth hydrophone is the shallowest. If 0 is entered, the shallowest hydrophone is used.
NOTE: Wind omni for a horizontal array is computed at the array depth. Wind omni for a vertical array is computed at the reference hydrophone depth. Shipping omni for both horizontal and vertical arrays is determined by the median value over all hydrophones.
{none}
[0, NHYD]

Array heading — Array heading clockwise from north.
{deg}
[0, 360]

4.4 Shipping Noise

Ship flag — Flag for calculation of shipping contribution.
y = compute the noise due to shipping
n = do not compute the noise due to shipping
If "n" is chosen, the following shipping inputs and PE inputs will be read, but will be ignored: ship depth, reference hydrophone, source level, range max, range min, ship extraction, number ships, random seed, range factor, depth factor, starter, number Pade and half beam-width.
{character*1}

[y or n]

Range min	Minimum range for shipping propagation. {m} [≥ 0]
Range max	Maximum range for shipping propagation. {m} [> Range minimum]
Ship depth	Ship source depth. This value will usually be 6 meters, the average propellor depth of a merchant ship. {m} [≥ 0]
Ship source levels	Ship source level calculations. 1 = RANDI II. The source is calculated by the RANDI II method. See reference 1. 2 = HITS 3.0. The source is calculated by the RANDI II method and then adjusted according to ship type. {none} [1 or 2]
Width	Sinc smoothing factor width for horizontal directionality plot. {deg} [0, 360]
Ship/Radial to Save	Enter which ship or radial to save. At this time, the model can only save the PE transmission loss field plot for 1 ship or radial. If 0 is entered the last radial or last ship will be saved for the last dead reckon period. If no ships were found on the radial chosen, this will result in an empty field plot file.

4.5 Shipping Data

Ship extraction flag	Flag for extracting shipping information. y = extract shipping densities from the HITS database and generate discrete shipping locations about the receiver n = do not extract shipping information, use the existing ship location file named ships.dat (described in section 4.9) {character*1} [y or n]
Max number ships	Maximum number of ships allowed in ship noise calculations. (This number will be read, but ignored if Ship extraction flag = "n".) {none} [1,5000]
Random seed	Random number seed for calculation of discrete shipping locations. (This number will be read, but ignored if Ship extraction flag ="n".) {none} [a large odd number, no limit]

4.6 Beamforming

Beamformer type
Flag for beamformer.
1 = Discrete Fourier Transform (DFT)
2 = Fast Fourier Transform (FFT)
3 = Volumetric (see section 4.10 for further information)
{none}
[1, 2, or 3]

Number of Beams
Number of beams. If an FFT beamformer, the number of beams must equal the number of hydrophones.
{none}
[2,256 for DFT, 2**N for FFT where N=1,2,3,...,7]

Shade flag
Flag to specify array shading.
1 = Hann
2 = Hamming
3 = Uniform
4 = Blackwell
{none}
[1, 2, 3, or 4]

4.7 Dead Reckoning

Number dead reckons
Number of dead reckonings. If number of dead reckons is chosen to be 0 the ships will not move and the field will be calculated for the initial time period. If number of dead reckons is chosen to be 1, the model will run 2 time periods, the initial field with no movement, then it will move the ships and run again.
{none}
[0, 9]

Dead reckon increment
Dead reckon time increment. If number of dead reckons is 0 this variable will be read but ignored.
{hr}

Array headings for dead reckons
Array heading with respect to due north for each dead reckon time period. (Note: The Array Heading input described in section 3.1 represents the initial time period.) If number of dead reckons is 0, this input will be read but ignored. If number of dead reckons > 0, this input will contain array headings for each dead reckon period.
{deg}
[0, 360] for each dead reckon increment

4.8 Wind Noise

Wind flag
Flag for calculation of wind contribution.
y = compute the noise due to wind
n = do not compute the noise due to wind
If "n" is chosen, the following wind inputs (windspeed and KI model flag) will be read, but will be ignored.

{character*1}
[y or n]

Extract Windspeed

Flag to extract windspeed from the Historical Windspeed database.
y = extract windspeed
n = use user input windspeed
{character*1}
[y or n]

Windspeed

Windspeed. Only used if wind flag="y" and extract windspeed="n".
{kts}
[1,90]

KI model flag

Flag for running the Kuperman-Ingenito wind model.
y = run the Kuperman-Ingenito wind model
n = do not run the Kuperman-Ingenito wind model.
NOTE: If wind flag = "y" and KI model flag = "n" there must be a wind model output file named windcon.dat in the run directory.
{character*1}
[y or n]

4.9 Flow Noise

Flow flag

Flag for calculation of flow contribution.
y = compute the noise due to flow
n = do not compute the noise due to flow
if "n" is chosen, the following flow input (tow speed) will be read, but will be ignored.
{character*1}
[y or n]

Tow speed

Tow speed.
{kts}
[5, 18]

4.10 System Noise

System flag

Flag for calculation of system contribution.
y = compute the noise due to system
n = do not compute the noise due to system
if "n" is chosen, the following system inputs (level, correlation length) will be read, but will be ignored.
{character*1}
[y or n]

System level

System noise power at hydrophone level.
{dB re 1 $\mu Pa/Hz^{1/2}$}

Correlation length

System noise correlation length.
{m}

4.11 Tow Ship Noise

Tow flag — Flag for calculation of tow ship contribution.
y = compute the noise due to tow ship
n = do not compute the noise due to tow ship
if "n" is chosen, the following tow ship inputs (level, set back, depth) will be read, but will be ignored.
{character*1}
[y or n]

Tow ship source level — Source level of tow ship.
{dB}

Tow ship array set back — Distance from tow ship to array.
{km}

Tow ship depth — Depth of tow ship.
{m}
[dependent on bathymetry of area]

4.12 Environmental Data

Class BLUG flag — Use unclassified or classified BLUG?
c = extract bottom parameters from the Confidential Low Frequency Bottom Loss database
u = extract bottom parameters from the unclassified Consolidated BLUG database
{character*1}
[c or u]

Class DBDB flag — Use unclassified or classified bathymetry?
c = extract bathymetry from confidential DBDBC database
u = extract bathymetry from the unclassified ETOPO5 database
{character*1}
[c or u]

Bottom flag — Use BLUG/Hamilton bottom? (For shipping noise calculation only.) Currently, the Kuperman-Ingenito wind noise model uses a Hamilton bottom environment. If the user is doing a RANDI 3.1 run and this wind model is being used to compute the wind noise, the user is recommended to use the Hamilton bottom for the FEPE shipping noise calculation as well. The Hamilton bottom is quasi-range-dependent, in that some of it's parameters will not change over range. For a range-dependent RANDI 3.1 run with no wind, the user is recommended not to use the Hamilton bottom.
1 = extract bottom profile from BLUG, use Hamilton sediment, basement density, and attenuation
0 = extract bottom profile from BLUG, use extracted parameters for sediment, basement density, and attenuation
{none}
[0 or 1]

Sound Speed — Type of sound speed database.

database flag
1 = HOP GDEM.
2 = Levitus.
NOTE: Levitus will not be provided at some facilities.
{none}
[1 or 2]

Range independent flag
Run shipping calculation range independent?
1 = range independent
0 = range dependent
{none}
[0 or 1]

4.13 Propagation

PE option flag
Flag to specify which propagation code to run.
0 = FEPE run for every ship. This is a brute force option.
1 = SSPE run for every ship. This is a brute force option.
2 = FEPE run for specified number of radials. The area defined for processing ships is divided into a number of radial sectors. The FEPE model is executed once for a user-defined radial contained within a sector and all ship contributions for that sector are computed using the complex pressures computed along that radial. This is the radial option.
3 = FEPE run for each sector as described in the radial option. In addition, within each sector a high resolution mode is used to determine the contribution of the individual ships based on their locations. This is the high resolution option.
{none}
[0, 1, 2, or 3]

Number of radials
Enter number of radials to run if PE Option flag is 2 or 3. (If PE option flag is not 2 or 3, this number will be read but not used.)
{none}
[0 to 360]

Radial sectors
Use constant or user-defined radial increments?
(If PE option flag is not 2 or 3 this input will be read but not used.)
y = use constant increments for radial bearings. Computed automatically by dividing 360 by the total number of radials.
n = use user-defined start bearing, end bearing, and extraction bearing for each radial
{character*1}
[y or n]

Number Pade terms
Number of Pade terms to use in FEPE calculation. For recommendations see FEPE documentation. If SSPE option was chosen this number will be read but not used.
{none}
[1 to 7; Note: the higher the Pade term, the longer the execution time.]

PE starter
PE starter type.
1 = Gaussian
2 = Green's

3 = Mode
4 = Image
5 = User specified
For recommendations see FEPE or SSPE documentation.
{none}
[1, 2, 3, 4 or 5]

Half beam-width Half beam-width for PE mode starter only. If the mode starter is not chosen, this number will be read but ignored.
{deg}
[0, 90]

Range Factor Factor of wavelength for PE range step. If range factor is set to 0 the PE range step (DR) will be set to wavelength, otherwise it will be range factor * lambda.
{none}

Depth Factor Factor of wavelength for PE depth step. If depth factor is set to 0 the PE depth step (DZ) will be set to wavelength/2, otherwise it will be depth factor * lambda.
{none}
[The depth step must be at least 20m, dz*wavelength<=20]

Sector bearings Start bearing, ending bearing, and extraction (propagation) bearing for each sector. (If PE option flag is not 2 or 3; or if PE option flag is 2 or 3, but radial increment option is "y," these records do not exist.) If input is "y," radial sector(s) will be determined automatically with equal angular increments. Each propagation bearing will run down the center of its sector. The propagation bearing is used to extract environmental information for the sector. If the input option is "n," radial sectors will be determined with user defined bearings. The following rules must be strictly adhered to: All sector bearings must be defined in the range 0 to 360 degrees. The sectors must be selected in the order of increasing bearing. The first sector must have the smallest start bearing of all the sectors. If a sector is to include the direction 360 degrees it must be the last sector. None of the sectors are allowed to overlap. The propagation (extraction or run) bearing of a sector must be between the start bearing and ending bearing of the sector.
{deg}
[0, 360]

4.14 Shipping Input File

Another input file, which is optional, is the shipping file. Within the input file mentioned above is an option to extract the shipping information or use the existing file. If a HITS 3.1 database extraction is not desired, the user may create his/her own shipping file in the following format. The name of this file should always be *ships.dat* This file is not needed if the ship flag for calculating shipping noise (see section 4.4) is specified to be no, or if the ship flag is yes and the ship extraction flag is specified to be yes. An example of the file is shown in Figure 2.

Lat, Lon Lat: Receiver array latitude position.
{deg}
[see geographic coverage of databases section 3.0]

Lon: Receiver array longitude position.
{deg}
[see geographic coverage of databases, section 3.0]

SHIPS(I,J)

SHIPS(I,1): Ship latitude.
{deg}
[see geographic coverage of databases, section 3.0]
SHIPS(I,2): Ship longitude.
{deg}
[see geographic coverage of databases, section 3.0]
SHIPS(I,3): Ship heading from due North.
{deg}
[0, 360]
SHIPS(I,4): Ship speed.
{kts}
SHIPS(I,5): Ship length.
{ft}
SHIPS(I,6): Ship range from receiver.
{km}
SHIPS(I,7): Ship bearing from receiver from due North.
{deg}
[0, 360]

(Note: I - Ship counter, J - Ship parameter)

4.15 Volumetric Array Input File

Another input file, which is optional, is the volumetric array input file. If the volumetric beamforming option is chosen (see section 4.1), the user will need to provide a file named *volcoord* which provides information on the user's array. Although this option is primarily for a volumetric array, a linear or planar array can be defined as well. An example of this file is shown in Section 8 (Figure 20). The inputs in this file are:

Total number of hydrophones
Center array depth (m)
Coordinate system (Only Cartesian coordinates are available at this time.)
X, Y, and Z coordinates of hydrophone #1
X, Y, and Z coordinates of hydrophone #2
etc.

where:

x-axis is NORTH
y-axis is EAST
z-axis is positive down (increasing depth)

These coordinates were arrived at by assuming that the greatest dimension of the array is originally aligned along the x-axis (NORTH), the second greatest dimension is aligned along the y-axis (EAST), with the positive z-axis facing down.

In order to allow any desired orientation of the linear, planar, or volumetric arrays, the user is assumed to first tilt the array up or down about the y-axis, with the negative direction corresponding to an array tilt towards the water surface and the positive direction corresponding to tilt towards the bottom of the ocean. Once the correct tilt is obtained, the user rotates the array azimuthally about the z-axis (clockwise from North).

The beamforming algorithm for planar and volumetric arrays is a delay and sum beamformer. An incoming plane wave is assumed to come in from a particular direction, and the phases across the hydrophones are computed from the dot product of the incoming wavenumber and the position vector of each hydrophone with respect to the array center. For each hydrophone, the complex pressure from all the radial FEPE runs is then multiplied by the conjugate of the phase calculated for that particular direction, resulting in a complex product.

The output of the coherent beamformer is obtained by summing these complex products over all hydrophones, squaring the absolute value of the sum, and then normalizing by the square of the number of hydrophones. The output of the incoherent beamformer is obtained by adding the absolute value squared of each hydrophone complex product, thereby neglecting all phase information when adding. The incoherent output is also normalized by the square of the number of hydrophones.

The above process is repeated for look angles corresponding to any combination of tilt angles and azimuthal angles. A color contour plot can then be made with the collection of beamformer outputs. Note that the tilt angle is displayed as the negative of the previously defined convention in the array beam surface contour plots.

4.16 Wind Input File

The file windcorr.dat contains the cross correlation matrix at the array due to wind noise and is required if wind noise contributions are to be included in the ambient noise calculation. It is generated during model execution by running the Kuperman-Ingenito wind model. It may then be used as an input file in subsequent model simulations.

For a horizontal array, windcorr.dat contains the cross correlation matrix at the array in the form of power vs depth. In addition, for a vertical array, windcorr.dat also contains the complex cross spectral density values. Thus, the windcorr.dat file for horizontal and vertical arrays are not interchangeable as input to the model.

5.0 MODEL EXECUTION

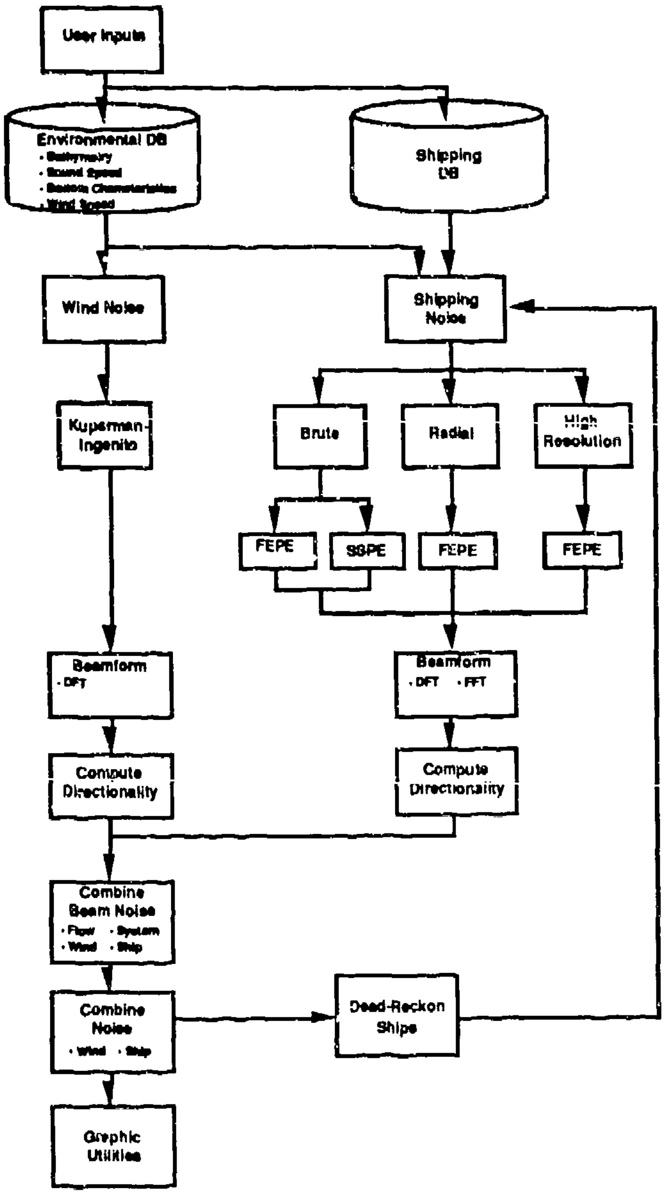
5.1 Command Format

The user may run the model by typing

pathname /exe/randi3.x

pathname is the path where the RANDI 3.1 model resides.

5.2 Model Flow Diagram



6.0 OUTPUT DESCRIPTION

The RANDI 3.1 model produces several output files which are described below.

6.1 Noise Field, Array Response, and Horizontal Directionality File

The main RANDI 3.1 output file (*main.out*) contains the beam headings, array response, noise field and horizontal directionality. Its format is shown in Table 6.1.

Table 6.1 RANDI 3.1 output file (*main.out*) format

Output Parameters	Description	Unit
FREQ, LAHD, NUMBMS, NHYD NUMS, IDUM, ZC	FREQ: Frequency LAHD: Heading of first dead reckoning NUMBMS: Number of beams NHYD: Number of hydrophones NUMS: Number of ships IDUM: Currently not in use ZC: Receiver depth	Hz deg - - - - m
IZERO, IONE, ALAT, ALON	IZERO: 0 IONE: 1 ALAT: Receiver latitude ALON: Receiver longitude	- - deg deg
TILT	Tilt angle of line array	deg
BHDS(i)	Beam headings (i=1,NUMBMS+1)	deg
For each time step (dead reckon):		
IONE	Paragraph marker for array response values = 1 always	-
XNOIS(i)	See note below (i=1,NUMBMS+1)	dB
SMFLD(i)	See note below (i=1,NUMBMS+1)	dB
OMN,DUM,WIDTH,LAH,OMNI	OMN: Coherent omnilevel for this noise field DUM: Currently not in use WIDTH: Smoothing factor width LAH: Heading for dead reckoning OMNI: Incoherent omnilevel	dB - deg deg dB
ITWO	Paragraph marker for noise field =2 always	-
YNOIS(N)	Noise field for each angle N=1,360	dB
SNOIS(N)	Smoothed noise field for each angle N=1,360	dB
OMN,DUM,WIDTH,OMNI, OMNW	OMN: Coherent omnilevel for this noise field DUM: Currently not in use WIDTH: Smoothing factor width OMNI: Incoherent omnilevel OMNW: Wind omnilevel	dB - deg dB dB
Only once:		
ITHREE	Paragraph marker for horizontal directionality =3	-
HZDIR(N)	Mean horizontal directionality for each angle N=1,360	dB
OMNM, DUM, WIDTH,DUM	OMNM: Omnilevel for mean horizontal directionality DUM: Currently not in use WIDTH: Smoothing factor width for horiz dir calculation DUM: Currently not in use	dB - deg -

Note: If using a Discrete Fourier Transform beamformer:
For the brute and radial methods, XNOIS will be coherent array response, SMFLD will be incoherent response. For high resolution, XNOIS will contain wind, tow, flow, and system noise only, no shipping noise, and SMFLD will be the incoherent response of the shipping noise plus XNOIS.

If using a Fast Fourier Transform beamformer:
XNOIS will be wind, tow, flow and system beam noise (no shipping), and SMFLD will be fft shipping beam noise plus XNOIS.

6.2 Shipping Information File

The *ships.dat* (see Figure 2) file defines the discrete ship location and the attributes (velocity, length, bearing from receiver, range from receiver, and heading). This file is used as input into the RANDI 3.1 model, but can be created by the model if the extract shipping option is chosen (see Shipping Input File, section 4.13). This file can be plotted using hitsplt.x (see Geographic View of Discrete Shipping Display Program, section 7.4).

6.3 Wind Model File

The *windcorr.dat* file contains the Kuperman-Ingenito wind model cross correlation matrix output. It is only input into the RANDI 3.1 model if the user chooses to calculate noise due to wind. This file is created by the Kuperman-Ingenito wind model (see section 4.16).

6.4 Complex Pressures at Each Dead Reckoning Files

These files contain complex pressures at each depth increment for 360 azimuths around the receiver for each dead reckoning time increment. *azim_vs_dep_0.dat* contains the initial time period, *azim_vs_dep_1.dat* contains the first dead reckoning, *azim_vs_dep_2.dat* the second, etc. These files are output by the RANDI 3.1 model. Any one of these files can be displayed by dirplt.x (see 3-D Ambient Noise Field Display Program, section 7.12).

6.5 Processed Ships File

The *dr_ships.dat* file defines the discrete ship location and the attributes (velocity, length, bearing from receiver, range from receiver, heading, and source level) for each dead reckoning time increment. The ships listed in this file are the ones that RANDI 3.1 was able to use in its calculations. Ships contained in the shipping information file (ships.dat), that are not listed in this file, were ignored during processing because they were found to be blocked by land or out of the user-defined maximum range for propagation calculations. This file is created by the RANDI 3.1 model. See Figure 3 for an example of this file.

6.6 Error File

Another important output file is the file named *error.log*. Any program failures will be reported in the *error.log* file. If for any reason, a module of the model does not finish successfully, the corrupted field will not contribute to the total field. For example, if FEPE crashes for a particular ship, that ship will be skipped and the program will continue calculation as if that ship never existed. Also, if an environmental data extraction runs into land, ships beyond that point will be ignored.

6.7 Environment File

The *fepe_envl.dat* file is the environmental great circle path output file containing the shipping environment used for each radial and for each dead reckoning period that the RANDI 3.1 model processed. This environment is saved when the shipping propagation method is either FEPE or SSPE. The saved environment includes the run time frequency and the sound speed profiles, attenuations, and densities at each range step along the radial's great circle path. This file can be plotted using envplt.x (see Environmental Display Program, section 7.7).

6.8 Transmission Loss / Signal Level Curve Files

These files contain the transmission loss levels for the receiver depth from zero to the maximum range. The transmission loss file name generated by the FEPE model is called *fetl.out* and the file name generated by the SSPE model is called *petl.out.*. These files can be plotted using the tlplt.x program (see Transmission Loss Display Program, section 7.8). Note: the *fetl.out* file will contain signal level if the radial or high resolution option is chosen.

6.9 Transmission Loss / Signal Level Field Files

These files contain the transmission loss levels for all depths from zero to the maximum range. The transmission loss file generated by the FEPE model is called *fepe.out* and the file generated by the SSPE model is called *sspe.out* These files can be displayed using the fldplt.x program. (see Transmission Loss Field Plot Display Program, section 7.9). Note: the *fepe.out* file will contain signal level if the radial or high resolution option is chosen.

6.10 Omnilevels at Hydrophones File

The *omni.dat* file contains the coherent and incoherent omnilevels at each hydrophone for shipping noise. This file is created by the RANDI 3.1 model and can be plotted by using omni_ship.x (see Omni Noise Level Display Program, section 7.11).

6.11 Time File

The file named *time.log* is useful to see how long the RANDI 3.1 run took. The time log contains the start time and end time of the model run. (This is the elapsed time, not cpu time.) This file is created by the RANDI 3.1 model.

6.12 Flow Noise File

The *flow.dat* file contains the flow beam noise level intensity. This value is constant for all beam angles. This file is created by the RANDI 3.1 model.

6.13 Ship Noise File

The *ship_noise.out* file is structured similarly to the main RANDI 3.1 output file (main.out), described in section 6.1, with the exception that it contains the noise from shipping only. This file is created by the RANDI 3.1 model.

6.14 System Noise File

The *sys_noi.dat* file contains the system noise at each beam. This file is created by the RANDI 3.1 model.

6.15 Wind Noise File

The *wind_noise.out* file is structured similarly to the main RANDI 3.1 output file (main.out), described in section 6.1, with the exception that it contains the noise from the wind only. This file is created by the RANDI 3.1 model.

6.16 Pressure File

The *press.dat* file contains the pressures at each hydrophone. This file is created by the RANDI 3.1 model.

6.17 Cumulative Pressure File

The *save_press.dat* file contains the cumulative pressure at each ship. This file is created by the RANDI 3.1 model.

6.18 Vertical Directionality File

The *vert_dir.out* file contains vertical directionality output. This file is created by the vert_dir_dft and vert_dir_fft programs. See sections 7.13 and 7.14 for more information on the creation and plotting of this file.

6.19 Volumetric Array Beam Noise File

The *vol_dft.out* file contains the volumetric array beam noise. This file is created by RANDI 3.1 if the volumetric option was chosen as the beamformer type (section 4.1). See section 7.16 for information on the plotting of this file.

7.0 SUPPORT SOFTWARE AND GRAPHICS DESCRIPTIONS

Many of the RANDI 3.1 model's output files contain data that can be displayed. Plots available include an environmental display, a ship display, a dead reckoned ship display, a transmission loss display at the receiver depth, a transmission loss field display, array response, noise field, and horizontal directionality displays, and an omni noise level display.

All of the graphics for RANDI 3.1 were written using the GKS graphics package version 4.1. All of the graphics programs described below have the option of creating either screendumped or postscript files which can be sent to printers which handle this type of output. When a plot is on the terminal screen, the user uses the SELECT button on the mouse to choose one of the following options from the popup menu: REPLOT, SCREENDUMP, POSTSCRIPT, EXIT. The Replot option produces the plot on the screen again. The Screendump option performs a screendump, outputting a raster file generally named fldplt.ras unless otherwise noted below. The Postscript option creates a postscript file (see Output Files sections below for names). The Exit option clears the screen, and in most cases, stops execution.

Below is a description of each display, and instructions for the generation of each display. Examples of the displays are shown in the various figures following Section 8.0. Input and output files for each display are given, with filenames in *italics* denoting user-specified filenames.

7.1 Bathymetry Extraction Program

The bathymetry extraction program extracts the water depths for a geographic area. The output from the program can be displayed in a color plot described in the next section. The program can extract from either the ETOPO5 or DBDBC databases.

Program Definition

Name:	areadb.f
Location:	*pathname*/source/plot/bathyplt
Compile and Link:	make
Run Instructions:	*pathname*/exe/areadb.x

Input Files

none

Interactive Inputs

Query: ***Enter south latitude:
Response: The user enters the southern latitude of the rectangular plot.{deg} [-90.0 to 90.0]

Query: ***Enter north latitude:
Response: The user enters the northern latitude of the rectangular plot.{deg} [-90.0 to 90.0]

Query: ***Enter west longitude:
Response: The user enters the western longitude of the rectangular plot.{deg} [-180.0 to 180.0]

Query: ***Enter east longitude:
Response: The user enters the eastern longitude of the rectangular plot.{deg}

[-180.0 to 180.0]

Query: ***Enter lat/lon increment:
Response: The user enters the increment for the extraction.{deg}
[minimum resolution=0.083333]

Query: ***Confidential [y/n]:
Response: The user enters the type of database to extract from. If the user enters "y", the DBDBC bathymetry database is used and the output is confidential. If the user enters "n", the ETOPO5 bathymetry database is used and the output is unclassified. {character*1)[y or n]

Output Files

areadb.out
The areadb.out file defines the bathymetric area. It contains the latitude, longitude, and depth for each point to be plotted.

7.2 Geographic View of Bathymetry Display Program

The bathymetry display program plots the bathymetry contours using a color plot on a geographic scale. Before this plot can be displayed, the bathymetric area must be extracted from either the ETOPO5 or DBDBC databases by areadb.x (section 7.1). This program then plots the display on the SUN Computer and the user is given a choice to create a hard copy of the display or to exit the program. See Figure 5 for an example of this display.

Program Definition

Name: bathyplt.f
Location: *pathname*/source/plot/bathyplt
Compile and Link: make
Run Instructions: *pathname*/exe/bathyplt.x

Input Files

file.in
The RANDI 3.1 input file described in section 3.0.

areadb.out
The areadb.out file defines the bathymetric area. It contains the latitude, longitude, and depth for each point to be plotted. The creation of this file is described in section 7.1.

color_palette.in (optional)
The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query: ***Enter the RANDI 3.1 input file name (a60):
Response The user enters the model run input file. {none} [character*60]

Query: ***Enter bathymetric input file name (a60)[areadb.out]:
Response The user enters bathymetric input file, default is areadb.out. {none} [character*60]

Query: ***Color Choices:
1. 15 Colors
2. 15 Grays
3. User defined palette
***Enter choice:

Response: The user enters the type of color scale to use. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none} [1 to 3]

If Color Choice is User Defined Palette:

Query: ***Enter color palette file name:

Response: The user enters the color palette file name. {none} [character*60]

Query: ***The minimum value for bathymetry is xxx, the maximum is xxx.
***Enter minimum legend level:

Response: The user enters the minimum value of bathymetry to plot {m}[dependent on bathymetry of area]

Query: ***Enter legend increment:

Response: The user enters the increment value of bathymetry loss to plot {m}[dependent on bathymetry of area]

Query: ***Enter south latitude:

Response: The user enters the southern latitude of the rectangular plot.{deg} [-90.0 to 90.0]

Query: ***Enter north latitude:

Response: The user enters the northern latitude of the rectangular plot.{deg} [-90.0 to 90.0]

Query: ***Enter latitude increment:

Response: The user enters the latitude increment for the plot.{deg} [>0.0 to <=90.0]

Query: ***Enter west longitude:

Response: The user enters the western longitude of the rectangular plot.{deg} [-180.0 to 180.0]

Query: ***Enter east longitude:

Response: The user enters the eastern longitude of the rectangular plot.{deg} [-180.0 to 180.0]

Query: ***Enter longitude increment:

Response: The user enters the longitude increment for the plot.{deg} [>0.0 to <=180.0]

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the bathymetry plot.

bathyplt.ps

The bathyplt.ps file is the postscript file of the bathymetry plot.

7.3 Geographic View of Bathymetry with Radial Display Program

The bathymetry with radial display program plots bathymetry and optionally the radials that are defined in the RANDI 3.1 input file. Another option is to display the extracted and processed ship locations on the geographic plot. These are the ship positions used as inputs in the RANDI 3.1 model and the ships that are processed by the model. The program plots the display on the SUN Computer and the user is given a choice to create a hard copy of the display or to exit the program. See Figure 6 for an example of this display.

Program Definition

Name:	bathygcp.f
Location:	*pathname*/source/plot/bathygcp
Compile and Link:	make
Run Instructions:	*pathname*/exe/bathygcp.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

ships.dat (optional)

The ships.dat file defines the ships discrete location and the ships attributes (velocity, length, bearing from receiver, range from receiver, and heading). This file is used as input into the RANDI 3.1 model.

dr_ships.dat (optional)

The dr_ships.dat file defines the ships discrete location and the ships attributes (velocity, length, bearing from receiver, range from receiver, heading, and source level) for each dead reckoning time increment. The ships listed in this file are the ones that RANDI 3.1 was able to use in its calculations. This file is created by the RANDI 3.1 model.

areadb.out

The areadb.out file defines the bathymetric area. It contains the latitude, longitude, and depth for each point to be plotted. The creation of this file is described in section 7.1.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query:	***Enter the RANDI 3.1 input file name (a60):
Response	The user enters the model run input file. {none}[character*60]
Query:	***GCP OPTIONS: 1. Do not plot GCPs 2. Plot GCPs ***Enter gcp option number:
Response	The user enters the great circle path plotting option number. If the user wants to see the input radials displayed geographically 2 is chosen. Otherwise, 1 is chosen to skip this option. {none}[1 or 2]

If GCP Option is Plot GCPs:

Query: ***BEARING OPTIONS:
1. Constant bearing increment
2. User defined bearings
***Enter bearing option number:

Response The user enters the bearing option. The user chooses option 1 for radials with a constant bearing increment or 2 to display the radials defined in the RANDI 3.1 input file. {none}[1 or 2]

If Bearing Option is Constant bearing increment:

Query: ***Enter start bearing [0,360]:

Response The user enters the start bearing.{deg}[0 to <360]

Query: ***Enter end bearing [0,360]:

Response The user enters the end bearing.{deg}[>start bearing to 360]

Query: ***Enter bearing increment [0,360]:

Response The user enters the bearing increment.{deg}[>0 to <360]

(End of Constant bearing increment option)

(End of Plot GCP Option)

Query: ***Enter 1 to plot shipping file:

Response The user enters 1 to plot the shipping file, 0 to skip this option.{none}[0 or 1]

If the option of plotting the shipping file is chosen:

Query: ***Enter 1 to highlight ships:

Response The user enters 1 to highlight ships that were not processed by RANDI 3.1, 0 to skip this option. {none}[0 or 1]

Query: ***Enter bathymetric input file name (a60) [areadb.out]:

Response The user enters the bathymetric input file name.{none}[character*60]

Query: ***Color Choices:
1. 15 Colors
2. 15 Grays
3. User defined palette
***Enter choice:

Response: The user enters the type of color scale to use for the bathymetry. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none} [1 to 3]

If Color Choice is User Defined Palette:

Query: ***Enter color palette file name:

Response: The user enters the color palette file name. {none} [character*60]

Query: ***Enter minimum legend level:

Response: The user enters the minimum value of bathymetry to plot {m}[dependent on bathymetry of area]

Query: ***Enter legend increment:

Response:	The user enters the increment value of bathymetry loss to plot {m}[dependent on bathymetry of area]

Query:	***Enter south latitude:
Response:	The user enters the southern latitude of the rectangular plot.{deg}[-90.0 to 90.0]

Query:	***Enter north latitude:
Response:	The user enters the northern latitude of the rectangular plot.{deg}[-90.0 to 90.0]

Query:	***Enter latitude increment:
Response:	The user enters the latitude increment for the plot.{deg}[>0.0 to <90.0]

Query:	***Enter west longitude:
Response:	The user enters the western longitude of the rectangular plot.{deg} [-180.0 to 180.0]

Query:	***Enter east longitude:
Response:	The user enters the eastern longitude of the rectangular plot.{deg} [-180.0 to 180.0]

Query:	***Enter longitude increment:
Response:	The user enters the longitude increment for the plot.{deg}[>0.0 to <180.0]

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the bathymetry with radials plot.

bathygcp.ps

The bathygcp.ps file is the postscript file of the bathymetry with radials plot.

7.4 Geographic View of Discrete Shipping Display Program

The ship display program plots the discrete ship locations extracted and/or processed by RANDI 3.1 in a rectangular plot. These are the ship positions used as inputs in the RANDI 3.1 model. The program plots the display on the SUN Computer and the user is given a choice to create a hard copy of the display or to exit the program. See Figure 7 for an example of this display.

Program Definition

Name:	hitsplt.f
Location:	*pathname*/source/plot/hit_db
Compile and Link:	make
Run Instructions:	*pathname*/exe/hitsplt.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

ships.dat

The ships.dat file defines the ships discrete location and the ships attributes (velocity, length, bearing from receiver, range from receiver, and heading). This file is used as input into the RANDI 3.1 model.

dr_ships.dat (optional)

The dr_ships.dat file defines the ships discrete location and the ships attributes (velocity, length, bearing from receiver, range from receiver, heading, and source level) for each dead reckoning time increment. The ships listed in this file are the ones that RANDI 3.1 was able to use in its calculations. This file is created by the RANDI 3.1 model.

Interactive Inputs

Query:	***Enter the RANDI 3.1 input file name (a60):
Response	The user enters the model run input file. {none} [character*60]
Query:	***Options: 1. Extracted Ships 2. Processed ships only 3. Processed ships with ignored ships in red
Response:	The user enters 1 to plot all the ships found by the model, 2 to plot only the ships that were processed by the model, or 3 to plot both types of ships, highlighting in red the ships ignored by the RANDI 3.1 model because they were blocked by land or exceeded the minimum/maximum ship ranges. {none}[1 to 3]
Query:	***Enter south latitude:
Response:	The user enters the southern latitude of the rectangular plot.{deg}[-90.0 to 90.0]
Query:	***Enter north latitude:
Response:	The user enters the northern latitude of the rectangular plot.{deg}[-90.0 to 90.0]
Query:	***Enter latitude increment:
Response:	The user enters the latitude increment for the plot.{deg}[0.0 to 90.0]
Query:	***Enter west longitude:
Response:	The user enters the western longitude of the rectangular plot.{deg} [-180.0 to 180.0]
Query:	***Enter east longitude:
Response:	The user enters the eastern longitude of the rectangular plot.{deg} [-180.0 to 180.0]
Query:	***Enter longitude increment:
Response:	The user enters the longitude increment for the plot.{deg}[>0.0 to <180.0]

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the ship locations plot.

hitsplt.ps

The hitsplt.ps file is the postscript file of the shipping location plot.

7.5 Geographic View of Shipping Density Display Program

The shipping density display program plots the shipping densities using a color plot on a geographic scale. The densities are extracted from the HITS 3.1 database. The plot can display all shipping types or individually display tanker, large tanker, super tanker, fishing, or merchant shipping densities. The plot can also display the discrete ships that are input to RANDI 3.1. The program plots the display on the SUN Computer and the user is given a choice to create a hard copy of the display or to exit the program. See Figure 8 for an example of this display.

Program Definition

Name:	shipden.f
Location:	*pathname*/source/plot/shipden
Compile and Link:	make
Run Instructions:	*pathname*/exe/shipden.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

ships.dat (optional)

The ships.dat file defines the ships discrete location and the ships attributes (velocity, length, bearing from receiver, range from receiver, and heading). This file is used as input into the RANDI 3.1 model.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query: ***Plot Choices:
1. Enter lat, lon area
2. Compute area from RANDI 3.1 input file
***Enter choice:

Response: The user enters the type of area input in which to extract the shipping density. If the user enters 1, the shipping density will be extracted by a rectangular grid. If the user enters 2, the shipping density will be extracted by a source and maximum range around the source.{none}[range=1 to 2]

If Plot Choice is Enter lat, lon area:

Query: ***Enter site id:

Response: The user enters the site identification that will be plotted at the lower left-hand corner {none}[character*15]

Query: ***Enter season (1-4):

Response: The user enters the season to extract the shipping density for. {1=Winter,2=Spring,3=Summer,4=Fall}[1 to 4]

If Plot Choice is Compute area from RANDI 3.1 input file

Query: ***Enter the RANDI 3.1 input file name (a60):

Response The user enters the model run input file. {none}[character*60]

Query: ***Enter south latitude:
Response: The user enters the southern latitude of the rectangular plot.{deg}[-90.0 to 90.0]

Query: ***Enter north latitude:
Response: The user enters the northern latitude of the rectangular plot.{deg}[-90.0 to 90.0]

Query: ***Enter latitude increment:
Response: The user enters the latitude increment for the plot.{deg}[>0.0 to <90.0]

Query: ***Enter west longitude:
Response: The user enters the western longitude of the rectangular plot.{deg}
[-180.0 to 180.0]

Query: ***Enter east longitude:
Response: The user enters the eastern longitude of the rectangular plot.{deg}
[-180.0 to 180.0]

Query: ***Enter longitude increment:
Response: The user enters the longitude increment for the plot.{deg}[>0.0 to <180.0]

Query: ***Enter 1 to plot discrete shipping file (ships.dat):
Response: The user enters 1 to plot discrete shipping, 0 to ignore this option. {none}[0 or 1]

Query: ***Enter Ship Density to Plot:
1. Merchant
2. Tanker
3. Large Tanker
4. Fishing
5. Super Tanker
6. All Ships
7. Exit
***Enter choice:
Response: The user enters the type of shipping density to display. If choice 6 is entered the sum of all shipping types is plotted. If 1 to 5 is chosen, only that respective ship density type is plotted. Option 7 exits the program. {none}[1 to 7]

Query: ***Color Choices:
1. 15 Colors
2. 15 Grays
3. User defined palette
***Enter choice:
Response: The user enters the type of color scale to use. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none}[1 to 3]

If Color Choice is User Defined Palette:
Query: ***Enter color palette file name:
Response: The user enters the color palette file name. {none} [character*60]

Query: ***The minimum value for bathymetry is xxx, the maximum is xxx.
***Enter minimum legend level:
Response: The user enters the minimum shipping density level to plot {ships/one deg}

Query: ***Enter legend increment:
Response: The user enters the shipping density level increment for the plot {ships/one deg}

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the shipping densities plot.

shipden*.ps

The shipden*.ps file is the postscript file of the shipping densities plot.

7.6 Array Heading Surface Display Program

The array heading surface display program plots the array heading surface signal to noise improvement relative to broadside performance in color with a noise rose polar plot and an optional array heading rose polar plot (6). The program plots the display on the SUN Computer and the user is given a choice to create a hard copy of the display or to exit the program. See Figure 9 for an example of this display.

Program Definition

Name:	ahs.f
Location:	*pathname*/source/plot/ahs
Compile and Link:	make
Run Instructions:	*pathname*/exe/ahs.x

Input Files

main.out

The main.out file describes the type of hydrophone array used, the array response and noise field for each heading, and the mean horizontal directionality.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query: ***Enter width of search sector [0 to 180]:
Response: The user enters the width of the search sector to use. {deg}[character*60]
Query: ***Enter search sector bearing increment[1 to 360]:
Response: The user enters the search sector bearing increment. This determines the resolution of the plot 's y axis. {deg}[>0 to <360]

Query: Color Choices:
1. Default Color scale
2. Default Gray scale
3. User defined palette
Enter choice:
Response: The user enters 1 to use the default color scale, 2 to user the default gray scale, or 3 for the user-defined palette.
{none}[1 to 3]

If Color Choice is User Defined Palette:
Query: ***Enter color palette file name:
Response: The user enters the color palette file name. {none} [character*60]

Query: Array Heading Surface color scale:
min=-10.0, max=5.0, redefine?
Response: The user enters "y" to redefine the color scale, "n" to keep -10 to 5. {character*1} [y or n]

If the user enters "y" to redefining the color scale:
Query: enter new minimum value:
Response: The user enters desired minimum value {dB}

Query: enter new maximum value:
Response: The user enters desired maximum value {dB}

Query: ***Plot Array Heading Rose? (y/n):
Response: The user chooses whether or not to plot the array heading rose. {character*1} [y or n]

If the user enters "y" to plotting array heading rose:
Query: ***Enter Array Heading Rose center of search sector:
Response The user enters the center of the search sector in degrees. {deg}[0 to 360]

Query: ***Enter minimum Array Heading Rose axes label:
Response: The user enters the value at the center of the polar plot. {dB}

Query: ***Enter maximum Array Heading Rose axes label:
Response: The user enters the value of the maximum range of the polar plot. {dB}

Output Files

fldplt.ras
The fldplt.ras file is the screendumped raster file of the array heading display plot.

ahs.ps
The ahs.ps file is the user specified postscript file of the array heading display plot.

7.7 Environmental Display Program

The environment display program plots the environmental input file used by the FEPE model. The input file is generated for each ship or radial that is processed. It displays the water column sound speed profiles and bathymetry along the great circle path from either the source to receiver or receiver to source direction. It displays the sound speed between 1450-1650 m/s. The dashed line indicates the sound channel axis, and the dotted line indicates the critical depth. The output plot is displayed on a SUN Computer screen and the user is given the option to exit the plot or get a hardcopy. See Figure 10 for an example of this display.

Program Definition

Name: envplt.f
Location: *pathname*/source/plot/env
Compile and Link: make

Run Instructions: *pathname*/exe/envplt.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

fepe_env1.dat

The fepe_env1.dat file is the output file containing the environment extractions for each ship or radial at each dead reckoning processed when running either FEPE or SSPE. The environment includes the frequency, profile ranges, profile sound speeds in the water, bottom, and sub-bottom attenuation and densities. The program returns an error and aborts if the user tries to plot a radial that was not processed.

Interactive Inputs

Query: ***Choice of plotting:
1. SRC to RCV
2. RCV to SRC
***Choose one:

Response: The user enters 1 to plot the environment from the source to the receiver location or 2 to plot the environment from receiver to source. {none}[1 to 2]

Query: ***Enter the RANDI 3.1 input file name (a60):

Response: The user enters the RANDI3.1 user input file name that was used to run the model. {none}[character*60]

Query: ***Enter the number of the dead reckoning to display [1 to NUMDR]:

Response: The user enters number of time period to display. The initial time period will be 1, the first dead reckoning 2, the second dead reckoning 3, etc. {none} [1 to NUMDR+1]

Query: ***Enter ship/radial number to display [1 to xxx]:

Response: The user enters number of the ship or radial to display. {none}[range=1 to NUMS/NRAD]

Query: ***Enter range minimum (km):

Response: The user enters the minimum range to plot. {km}[0 to <maximum range]

Query: ***Enter range maximum (km):

Response: The user enters the maximum range to plot. {km}[>0 to maximum range]

Query: ***Enter range increment (km):

Response: The user enters the range increment to label the plot. {km}[>minimum range to >maximum range]

Query: ***Enter depth minimum (km):

Response: The user enters the minimum depth to plot. {km}[0 to <maximum depth]

Query: ***Enter depth maximum (km):

Response: The user enters the maximum depth to plot. {km}[0 to >maximum depth]

Query: ***Enter depth increment (km):

Response: The user enters the depth increment to label the plot. {km}[>minimum depth to <maximum depth]

Output Files

fldplt.ras
The fldplt.ras file is the screendumped raster file of the environmental plot.

envplt.ps
The envplt.ps is the postscript plot file containing the environmental plot.

7.8 Transmission Loss / Signal Level Display

The transmission loss / signal level display program plots range versus transmission loss for the user specified ship or radial at the receiver depth. If the radial or high resolution options were selected, the program will plot range versus signal level. The transmission loss is calculated for the FEPE and SSPE options. Only signal level is only calculated for the FEPE option. The output from the transmission loss display is an interactive plot displayed on the SUN Computer. The user may then create a hard copy of the plot or exit the plot routine. See Figure 11 for an example of the display.

Program Definition

Name:	tlplt.f
Location:	*pathname*/source/plot/tl
Compile and Link:	make
Run Instructions:	*pathname*/exe/tlplt.x

Input Files

file.in
The RANDI 3.1 input file described in section 3.0.

fetl.out or petl.out
These files contain the transmission loss / signal levels for the receiver depth from zero to the maximum range. The transmission loss file name generated by the FEPE model is called fetl.out and the file name generated by the SSPE model is called petl.out.

Interactive Inputs

Query: ***Enter the RANDI 3.1 input file name (a60):
Response: The user enters the model run input file. {none}[character*60]

Query: ***Enter input transmission loss (TL) filename [fetl.out]:
Response: The user enters the name of the RANDI 3.1 transmission loss output file. (usually fetl.out if FEPE model was executed and petl.out if SSPE model executed). {none} [fetl.out or petl.out]

Query: ***Enter minimum TL level (dB):
Response: The user enters the minimum value of transmission loss / signal level to be plotted. {dB}

Query: ***Enter maximum TL level (dB):

Response:	The user enters the maximum value of transmission loss / signal level to be plotted. {dB}

Query:	***Enter TL increment level (dB):
Response:	The user enters the increment value of transmission loss / signal level to be plotted. {dB}

Query:	***Enter maximum range (km):
Response:	The user enters the maximum range to be plotted. {km}

Query:	***Enter range increment (km):
Response:	The user enters the range increment to be plotted. {km}

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the transmission loss / signal level plot.

tlplt.ps

The tlplt.ps file is a postscript file of the transmission loss / signal level plot.

7.9 Transmission Loss / Signal Level Field Plot Display

The transmission loss field / signal level plot program displays color levels of transmission loss for the user specified ship or radial on a range versus depth field. If the radial or high resolution method was used, signal level on a range versus depth field will be displayed. An asterisk is plotted at the source/ship depth (at range 0.) and at the receiver location and depth (near maximum range). The transmission loss is calculated for the FEPE or SSPE options. Only signal level is calculated for the FEPE option. The output from the transmission loss display is an interactive plot displayed on the SUN Computer. The user may then create a hardcopy of the plot or exit the plot. See Figure 12 for an example of this display.

Program Definition

Name:	fldplt.f
Location:	*pathname*/source/plot/fld
Compile and Link:	make
Run Instructions:	*pathname*/exe/fldplt.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

fepe.out or sspe.out

These files contain the transmission loss / signal levels for all depths from zero to the maximum range. The transmission loss file name generated by the FEPE model is called fepe.out and the file name generated by the SSPE model is called sspe.out.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the transmission loss field plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query: ***Enter the RANDI3.1 input file name (a60):
Response: The user enters the model run input file.{none}[character*60]

Query: ***Field Type Generator:
1. FEPE
2. SSPE
***Enter field type generator: [1 to 2]:
Response: The user selects the option used to generate the transmission loss input file. {none} [1 to 2]

Query: ***Maximum depth (km):
***Enter maximum depth (km):
Response: The user enters the maximum depth. {km}[<=maximum depth]

Query: ***Enter depth axis label increment (km):
Response: The user enters the depth axis increments. {km}[>0 to <maximum depth]

Query: ***Maximum range (km):
***Enter range axis label increment:
Response: The user enters the range axis increment. {km}[>0 to <maximum range]

Query: ***Output source and receiver lat, lon ? (y/n)
Response: The user enters "y" to write the latitude and longitude positions on the plot and "n" to not write the positions on the plot. {character*1}[y or n]

Query: ***Color Choices:
1. 15 Colors
2. 15 Grays
3. User defined palette
***Enter choice:
Response: The user enters the type of color scale to use. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none} [1 to 3]

If Color Choice is User Defined Palette:
Query: ***Enter color palette file name:
Response: The user enters the color palette file name. {none} [character*60]

Query: TL Range (dB) = xxx to xxx.
***Enter TL minimum:
Response: The user enters the minimum value of transmission loss / signal level to plot {dB}

Query: ***Enter TL maximum:
Response: The user enters the maximum value of transmission loss / signal level to plot {dB}

Output Files

fldplt.ras
The fldplt.ras file is the screendumped raster file of the transmission loss / signal level plot.

fldplt.ps

The fldplt.ps is the postscript file of the transmission loss / signal level plot.

7.10 Array Response, Noise Field, and Horizontal Directionality Display Program

The array response, noise field, and horizontal directionality display program creates polar plots of the RANDI 3.1 output. Horizontal directionality is not valid unless the ships were dead reckoned. All of the above plots are plotted relative to omni noise level at the user specified hydrophone. See Figure 13 for an example of the beam noise display, Figure 14 for an example of the spiked noise display and Figure 15 for an example of the smoothed noise display. Horizontal directionality was not plotted for the example run, because there were no dead reckons.

Program Definition

Name:	mainplot.f
Location:	*pathname*/source/plot/main
Compile and Link:	make
Run Instructions:	*pathname*/exe/mainplot.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

main.out

The main.out file describes the type of hydrophone array used, the array response and noise field for each heading, and the mean horizontal directionality.

Interactive Inputs

Query: ***Enter the RANDI 3.1 input file name (a60):
Response: The user enters the model run input file. {none}[character*60]

Query: ***OMNILEVEL REFERENCE:
1. Coherent.
2. Incoherent
***Enter reference option [1-2]:
Response: The user enters the omni reference type for the beam, spike, and horizontal directionality levels. This reference will be used if the "relative to omnilevel" option is chosen below. {none}[1 to 2]

Query: ***PLOTTING OPTIONS:
1. Beam Noise Plot
2. Spiked Shipping Noise Plot
3. Smoothed Shipping Noise Plot
4. Horizontal Directionality Plot
5. Exit
***Enter option [1-5]:
Response: The user enters the type of curve to plot. The valid choices are to plot the beam noise, spiked noise, smoothed noise, averaged horizontal directionality (if any dead reckonings were run), or to exit the entire program. {none}[1 to 5]

If Spiked noise option is chosen:
Query: ***Spiked Shipping Noise Plotting Options:

1. Plot as Spike
2. Plot as Curve
***Enter Option:

Response: The user enters 1 to plot shipping noise "spikes" and 2 to draw "curves". The spikes contain shipping noise only, the curves contain both wind and shipping noise. {none}[1 or 2]

If a Vertical Array is Processed:

Query: ***Vertical Beam Noise Options:
1. Dead Reckoning Period 0
2. Dead Reckoning Period 1
3. Exit
***Enter period option number [1-3]:

Response: The user enters the dead reckoning period option number he wishes to display. The number of periods depend on the RANDI 3.1 run. If the exit option is chosen, the user is returned to the Plotting Option Menu. This menu is only displayed if a vertical beam noise was generated. {none} [1 to 3].

If a Horizontal Array is Processed:

Query: ***Beam Noise Heading Options:
1. Heading 0 degrees
2. Heading 110 degrees
3. Exit
***Enter heading option number [1-3]:

Response: The user enters the heading option number he wishes to display. The number of headings depend on the RANDI 3.1 run. If the exit option is chosen, the user is returned to the Plotting Option Menu. This menu is only displayed if a horizontal beam noise was generated. {none} [1 to 3].

If a DFT beamforming type:

Query: ***DFT BEAMFORMING OPTIONS:
1. Coherent
2. Incoherent
***Enter option [1-2]:

Response: The user enters the type of beam levels to plot. If 1 is entered, the coherent beam pattern is plotted. If 2 is entered, the incoherent beam pattern is plotted. {none}[1 to 2].

Query: ***Plotting Scale Options:
1. Absolute
2. Relative to omnilevel
***Enter plotting scale option number

Response: The user enters 1 to use an absolute plotting scale, 2 to plot the data relative to the omnilevel. {none}[1 or 2]

If the Absolute plotting scale option is chosen:

Query: ***Enter minimum level (dB):

Response: The user enters the minimum omnilevel.{dB}

Query: ***Enter maximum level (dB):

Response: The user enters the maximum omnilevel.{dB}

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the array response, noise field, or horizontal directionality plot. Note: only one type of plot can be screendumped at a time because this file will be overwritten.

beam_noise_fft*.ps
beam_noise_coh**.ps
beam_noise_incoh**.ps
spiked_ship_noise**.ps
curve_ship_noise**.ps
smoothed_ship_noise**.ps
avg_hort_dir.ps

Listed above are the postscript output files of the polar plots. The filenames are descriptive of the user-specified choices. The ** will be the dead reckoning number chosen.

7.11 Omni Noise Level Display Program

The omni noise level display program plots hydrophone number versus omni noise level in dB on the SUN Computer. The user may then create a hard copy of the plot or exit the plot. See Figure 16 for an example of this display.

Program Definition

Name:	omni_ship.f
Location:	*pathname*/source/plot/omn
Compile and Link:	make
Run Instructions:	*pathname*/exe/omni_ship.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

omni.dat

The omni.dat file contains the coherent and incoherent shipping omnilevel at each hydrophone.

Interactive Inputs

Query:	***Enter the RANDI 3.1 input file name (a60):
Response:	The user enters the name of the input file that RANDI 3.1 was run with. {none} [character*60]
Query:	***Enter 0 for coherent omni, 1 for incoherent:
Response:	The user enters 0 to plot coherent omni and 1 to plot incoherent omni. {none} [0 or 1]
Query:	***Enter dead reckon number to plot, or enter 99 to stop:
Response:	The user enters the time period to plot or 99 to stop. {none}[1,NUMDR+1]
Query:	***Range of omni is xxx to xxx.

***Enter min omni:

Response: The user enters the minimum omnilevel to be displayed on the plot. {dB}

Query: ***Enter max omni:

Response: The user enters the maximum omnilevel to be displayed on the plot. {dB}

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the omni plot.

omni.ps

The omni.ps file is a postscript file of the omni noise level plot.

7.12 3-D Ambient Noise Field Display

The 3-D ambient noise field display contains a number of plots. There is a full field color shade plot of the ambient noise with respect to depth and azimuth around the receiver, a line plot of the noise versus depth, and three polar plots of horizontal directionality at user-specified depths. The program input is computed by the RANDI 3.1 model. The output from the display is an interactive plot displayed on the SUN Computer. The user may then create a hardcopy of the plot or exit the plot. See Figure 17 for an example of this display.

Program Definition

Name: dirplt.f

Location: *pathname*/source/plot/dir

Compile and Link: make

Run Instructions: *pathname*/exe/dirplt.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

azim_vs_dep_0.dat, azim_vs_dep_1.dat, etc.

The azim_vs_dep_*.dat files contains complex pressures at each depth increment for 360 azimuths around the receiver for each dead reckoning. These files are output by the RANDI 3.1 model.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

windcorr.dat (optional)

The windcorr.dat file contains the Kuperman-Ingenito wind model cross correlation matrix output.

Interactive Inputs

Query: ***Enter the RANDI 3.1 input file name (a60):

Response: The user enters the model run input file. {none}[character*60]

Query: ***Enter name of the ship pressure file (a60)(azim_vs_dep_dr.dat, where dr=1,ndr):

Response: The user enters the file name of the ambient noise file. For the first dead reckoning the file azim_vs_dep_0.dat is entered, for the second dead reckoning, file azim_vs_dep_1.dat is entered, etc.
{none}[character*60]

For horizontal wind:

Query: ***Wind omnilevel (Constant with depth) (dB):

Response: The user enters the wind omnilevel. If no wind is displayed, set wind omni level to zero.{dB}

For vertical wind:

Query: ***Choices for Wind:
1. Wind intensity vs depth file
2. Constant wind intensity vs depth
***Enter choice:

Response: The user enters 1 to use a wind vs depth file, and 2 to use a constant wind.{none}
[1 or 2]

If Wind vs intensity file:

Query: ***Enter wind source level (dB):

Response: The user enters the wind source level. {dB}

Query: ***Enter name of wind intensity file (a60):

Response: The user enters the name of the file. {none}[character*60]

If constant wind:

Query: ***Wind omnilevel (Constant with depth) (dB):

Response: The user enters the wind omnilevel. If no wind is displayed, set wind omnilevel to zero.{dB}

Query: ***Enter depth axis increment (m):

Response: The user enters the depth increment for the shade plot. The start depth is always zero meters. {m}

Query: ***Enter receiver depth(m):

Response: The user enters the receiver depth for which the horizontal directionality will be calculated for. This depth will be used to normalize the plots if the relative to omni option is used. {m} [dependent on bathymetry of area]

Query: ***Choice of vertical directionality output:
1. Relative (dB)
2. Absolute (dB)

Response: The user enters the type of vertical directionality level to output. If relative is chosen, the levels plotted will be with respect to omnilevel. If absolute is chosen, the absolute levels will be plotted. {none}[1 or 2]

Query: ***Color Choices:
1. 15 Colors
2. 15 Grays
3. User defined palette
***Enter choice:

Response: The user enters the type of color scale to use. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none} [1 to 3]

If Color Choice is User Defined Palette:
Query: ***Enter color palette file name:
Response: The user enters the color palette file name. {none} [character*60]

Query: 3 Depths of Interest for Noise vs Azimuth Plots
***Enter depth #1:
***Enter depth #2:
***Enter depth #3:
Response: The user enters three depths of interest for the noise vs azimuth polar plots. {m} [dependent on bathymetry of area]

Output Files

fldplt.ras
The fldplt.ras file is the screendumped raster file of the 3-D ambient noise field plot.

dirplt.ps
The dirplt.ps file is the postscript file of the 3-D ambient noise field plot.

7.13 Vertical Directionality Calculation Programs

The vertical directionality calculation programs compute the vertical directionality and overall horizontal directionality for a RANDI 3.1 model run where the vertical array is centered on the user input depth. Only one dead reckoning period is computed. One vertical directionality calculation program uses a fast Fourier transform with a spacing of lambda/4 to compute the vertical beam pattern. This program sets the number of hydrophones to 2,4,8,16,32, or 64 depending on the water column depth. The program always tries to use 64 hydrophones first. It forms the same number of beams as there are hydrophones defined. The other vertical directionality program uses a discrete Fourier transform with user defined spacing. This program asks the user for the number of hydrophones to start with and then halves the number until the array fits into the water column. The output from these programs can be displayed on an ambient noise 3-D directionality display as described in the next section.

Program Definition

Name: vert_dir_fft.f or vert_dir_dft.f
Location: *pathname*/source/vert
Compile and Link: make
Run Instructions: *pathname*/exe/vert_dir_fft.x or vert_dir_dft.x

Input Files

file.in
The RANDI 3.1 input file described in section 3.0.

azim_vs_dep_0.dat, azim_vs_dep_1.dat, etc.
The fazim_vs_dep_*.dat files contain complex pressures at each depth increment for 360 azimuths around the receiver for each dead reckoning. These files are output by the RANDI 3.1 model.

omni.dat

The file omni.dat contains the coherent and incoherent shipping omnilevels at each hydrophone. The file is output by the RANDI3.1 model.

bathy1.dat (optional)

The bathy1.dat file contains the bathymetry at the receiver location. This file is output by the environmental extraction program.

Interactive Inputs

Query:	***Enter the RANDI 3.1 input file name (a60):
Response:	The user enters the model run input file. {none}[character*60]
Query:	The number of dead reckons calculated is xxx. ***Enter the dead reckon number to plot [0-9]:
Response:	The user enters the desired dead reckoning period for computing the vertical directionality. {none}[0 to number of dead reckons calculated]

If running vert_dir_dft.x, the following additional queries will appear:

Query:	***Enter hydrophone spacing (xxx):
Response:	The user enters the hydrophone spacing. {none}[dependent on bathymetry of area, usually a multiple of wavelength]
Query:	***Enter number of hydrophones (xxx):
Response:	The user enters the maximum number of hydrophones for the vertical array. This number will be halved until the array fits in the water column. {none}

Output Files

vert_dir.out

The vert_dir.out file contains the vertical directionality level for each vertical beam at each azimuth, the overall vertical directionality, and the horizontal directionality.

vert_main.out

The vert_main.out file created by vert_dir_fft.f contains the vertical beam noise in a format that mainplot.x can read. The file vert_main.out should be renamed main.out before executing mainplot.x since main.out is the default file name.

7.14 Ambient Noise 3-D Directionality Display

The ambient noise 3-D directionality display contains a number of plots. There is the full field color shade plot of the vertical beam noise at each azimuth, the line plot of the vertical directionality, and the line plot of the horizontal directionality. The program input is computed by the vertical directionality program described in the previous section. The output from the display is an interactive plot displayed on the SUN Computer. The user may then create a hardcopy of the plot or exit the plot. See Figure 18 for an example of this display.

Program Definition

Name:	vertfld.f
Location:	*pathname*/source/plot/vert
Compile and Link:	make
Run Instructions:	*pathname*/exe/vertfld.x

Input Files

file.in

The RANDI 3.1 input file described in section 3.0.

vert_dir.out

The vert_dir.out file contains the vertical directionality level for each vertical beam at each azimuth, the overall vertical directionality, and the horizontal directionality.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query: ***Enter the RANDI 3.1 input file name (a60):
Response: The user enters the model run input file. {none}[character*60]

If vert_dir_fft.x was used to calculate the vertical directionality:

Query: ***3-D Plot:
1. Plot only real beams
2. Plot all beams
***Enter plotting option number:
Response: The user enters 1 to plot only the real beams, 2 to plot real and virtual beams. Note: virtual beams are only created for the fft beamformer.{none} [1 or 2]

Query: Horizontal Directionality range xxx to xxx dB re omni.
***Enter minimum (dB):
Response: The user enters minimum horizontal directionality level to plot. {dB}

Query: ***Enter maximum (dB):
Response: The user enters maximum horizontal directionality level to plot. {dB}

Query: ***Color Choices:
1. 15 Colors
2. 15 Grays
3. User defined palette
***Enter choice:
Response: The user enters the type of color scale to use. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none}[1 to 3]

If Color Choice is User Defined Palette:

Query: ***Enter color palette file name:
Response: The user enters the color palette file name.{none}[character*60]

Query: ***Vertical directionality field plot range = xxx to xxx dB re omni.
***Enter minimum range (dB):
Response: The user enters the minimum vertical beam level.{dB}

Query: ***Enter maximum range (dB):
Response: The user enters the maximum vertical beam level.{dB}

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the ambient noise 3-D field plot.

vertfld.ps

The vertfld.ps file is the postscript file of the ambient noise 3_D field plot.

7.15 AACDF Display Program

This display plots the azimuthal anisotropic cumulative distribution function (AACDF). The AACDF is a statistic that characterizes the noise field by emphasizing both the spatial and temporal influence of the noise field on a horizontal array (7). The AACDF plot displays the percentage of azimuth below a search sector level versus the broadband beamwidth. The output from the display is an interactive plot displayed on the SUN Computer. The user may then create a hardcopy of the plot or exit the plot. See Figure 19 for an example of this display.

Program Definition

Name:	aacdf.f
Location:	*pathname*/source/plot/aacdf
Compile and Link:	make
Run Instructions:	*pathname*/exe/aacdf.x

Input Files

main.out

The main.out file describes the type of hydrophone array used, the array response and noise field for each heading, and the mean horizontal directionality.

Interactive Inputs

Query:	***Which leg would you like to plot (1 - NDR+1):
Response:	The user enters the time period of interest where 1 is the initial time, 2 is the first dead reckoning, 3 is the second dead reckoning, and through the total number of dead reckonings+1.{none}
Query:	Minimum Azimuthal Level is xxx. Maximum Azimuthal Level is xxx. ***Enter minimum azimuthal level (dB):
Response:	The user enters the minimum level to plot. This value must be greater than or equal to the minimum level shown in the query.{dB}
Query:	***Enter maximum azimuthal level (dB)
Response:	The user enters the maximum level to plot. This value must be less than or equal to the maximum level shown in the query.{dB}
Query:	***Enter azimuthal level increment (dB):
Response:	The user enters the plotting increment {dB}.

Output Files

aacdf.ras

The fldplt.ras file is the screendumped raster file of the aacdf plot.

aacdf.ps

The aacdf.ps file is the postscript file of the aacdf plot.

7.16 Volumetric Array Beam Surface Display

This display plots the full field color shade plot of the volumetric array beam surface. The output from the display is an interactive plot displayed on the SUN Computer. The user may then create a hardcopy of the plot or exit the plot. See Figure 21 for an example of this display.

Program Definition

Name:	vol_beam_surf.f
Location:	*pathname*/source/plot/volume
Compile and Link:	make
Run Instructions:	*pathname*/exe/vol_beam_surf.x

Input Files

vol_dft.out

The vol_dft.out file contains the volumetric beam noise.

color_palette.in (optional)

The file *color_palette.in* defines the color palette the user wishes to use when displaying the color plot. The file is an optional input. The user can use the default color or gray scale palette.

Interactive Inputs

Query: ***Enter the plot input file name (a60):

Response: The user enters the input file name, which will be *vol_dft.out* unless the user has changed it. {none}[character*60]

Query: ***Color Choices.
1. 15 Colors
2. 15 Grays
3. User defined palette
4. Exit
***Enter choice:

Response: The user enters the type of color scale to use. Option 1 uses the colors from blue to red. Option 2 displays a gray scale. And option 3 allows the user to define his own color scheme by entering a color palette file name. {none}[1 to 3]

If Color Choice is User Defined Palette:

Query: ***Enter color palette file name:

Response: The user enters the color palette file name.{none}[character*60]

Query. ***Enter minimum color legend level:

Response: The user enters the minimum beam level.{dB}

Query: ***Enter legend color increment:
Response: The user enters the beam level increment. {dB}

Output Files

fldplt.ras

The fldplt.ras file is the screendumped raster file of the volumetric beam noise plot.

vol_beam_surf.ps

The vol_beam_surf.ps file is the postscript file of the volumetric beam noise plot.

7.17 Summary of RANDI 3.1 Graphics Routines

The table in this section provides the user with a concise summary of the graphics routines available for analyzing output from a model execution and described in detail in previous sections.

Table 7.1 Summary of RANDI 3.1 Graphics Routines

Executable	Plot Title	Function	Input Files Required	Databases Required
areadb.x (Sec. 7.1)	None	Extracts bathymetry over user-defined latitudes and longitudes. Creates file areadb.out.	None	ETOPO5 or DBDBC
bathyplt.x (Sec. 7.2)	Geographic View of Bathymetry	Color plot of bathymetry using areadb.out file.	* Randi3.1 input file * areadb.out	None
bathygcp.x (Sec. 7.3)	Geographic View of Bathymetry (and Shipping)	Color plot of bathymetry. User may choose to plot the receiver location and the extracted and processed ships.	* Randi3.1 input file * areadb.out * ships.dat * dr_ships.dat	ETOPO5 or DBDBC
hitsplt.x (Sec. 7.4)	Geographic View of Discrete Shipping	Plot of discrete shipping on a latitude/longitude grid.	* Randi3.1 input file * ships.dat * dr_ships.dat	None
shipden.x (Sec. 7.5)	Geographic View of Shipping Lanes	Color plot of HITS shipping densities over a latitude/longitude grid. User may plot discrete ships also.	* Randi3.1 input file * ships.dat	HITS
ahs.x (Sec. 7.6)	Array Heading Surface	Color plot of SNR gain over broadside for different bearings as a function of array heading. Includes supplemental plot of noise rose and optional plot of array heading rose.	* main.out	None
envplot.x (Sec 7.7)	Environmental Cross-Section For Specific Radial	Plots bathymetry and sound speed profile for a ship or radial. Marks critical depth and sound channel axis.	* Randi3.1 input file. * fepe_all.inl	None
tlpl..x (Sec. 7.8)	FEPE TL	Transmission loss vs range for the one radial specified in the Randi3.1 input file.	* Randi3.1 input file * fetl.out or petl.out	None
fldplt.x (Sec. 7.9)	Transmission Loss or Pressure Level	Color plot of transmission loss or signal level over depth and range.	* Randi3.1 input file * fepe.out or sspe.out	None
mainplot.x (Sec. 7.10)	Beam Noise	Polar plot of beamformed noise.	* Randi3.1 input file * main.out	None
mainplot.x (Sec. 7.10)	Shipping Noise Field	Polar spike plot of noise level due to individual ships.	* Randi3.1 input file * main.out	None
mainplot.x (Sec. 7.10)	Smoothed Shipping Noise Field	Sinc smoothed polar spike plot of noise level due individual ships.	* Randi3.1 input file * main.out	None
mainplot.x (Sec. 7.10)	Time Avg Horizontal Directionality	Polar plot of horizontal directionality averaged over all dead reckon increments.	* Randi3.1 input file * main.out	None
omni_ship.x (Sec. 7.11)	Hydrophone Shipping Noise Level	Plots incoherent or coherent omnilevel vs hydrophone.	* Randi3.1 input file * omni.dat	None

dirplt.x (Sec. 7.12)	Ambient Noise: Azimuth vs Depth	Color plot of shipping and wind noise over azimuth and depth, three horizontal directionality noise plots at selected depths, and a plot of noise vs depth.	* Randi3.1 input file * azim_vs_dep_*.dat (shipping pressure files for each dead reckon * windcorr.dat	None
vertfld.x (Sec. 7.14)	Ambient Noise 3-D Directionality	Color plot of noise level over azimuth vs elevation angle (vertical noise field), and line plots of vertical and horizontal directionality.	* Randi3.1 input file * vert_dir.out (created external to Randi3.1)	None
aacdf.x (Sec. 7.15)	Azimuthal Anisotropic Cumulative Distribution Function	Percentage of occurrence in azimuth of spatial noise holes as a function of beamwidth.	* main.out	None
vol_beam_surf.x (Sec. 7.16)	Volumetric Array Beam Surface	Beam noise over elevation angle and azimuth.	* vol_dft.out	None

8.0 RANDI 3.1 EXAMPLE RUN DESCRIPTION

A RANDI 3.1 sample run is presented below. The extraction site is located in the Oman area, the Port of Chah Bahar at 25N, 60.3E. The season is summer. The run frequency is 50 Hz. A horizontal line array is located on the bottom at 978 m depth with a heading of 0 degrees north. The array consists of 64 hydrophones spaced 12.2 m apart. Both shipping and wind noise are calculated. Ships are extracted to a maximum range of 5000 km. The FEPE model uses range and depth increments equal to 0.5 and 0.25 times the wavelength, respectively, and uses a Gaussian starter and 1 Pade term. The wind model is run with a windspeed of 10 kts and a wind source depth of 6 m. The noise field is smoothed with a 10 degree smoothing factor width. No dead reckonings were used in this run.

The following figures show the inputs and outputs of this run. Specifically, Figures 1 - 4 and 20 contain text input and output files generated by RANDI 3.1, and Figures 5 - 19 and 21 contain RANDI 3.1 output graphics. This example takes approximately 14 hours to run using a SUN SparcStation 2.

RANDI 3.1 User Input File

```
!                    FREQUENCY
   50.00                    !  FREQUENCY (Hz) [0,10000]
!                 LOCATION PARTICULARS
OMAN AREA                   !  SITE IDENTIFICATION [15 CHARACTERS]
   25.00                    !  RECEIVER LATITUDE (deg +N) [0,85]
   60.30                    !  RECEIVER LONGITUDE (deg +E) [-180,180]
       3                    !  1=WINTER, 2=SPRING, 3=SUMMER, 4=FALL
 1500.00                    !  REFERENCE SOUND SPEED (m/s) [1200,1800]
!                 ARRAY PARTICULARS
    0.00                    !  0.=HORIZONTAL ARRAY, 90.=VERTICAL ARRAY
      64                    !  NUMBER OF HYDROPHONES [2,256]
   12.20                    !  HYDROPHONE SPACING (m)
  978.00                    !  ARRAY CENTER DEPTH (m)
       1                    !  REFERENCE HYDROPHONE NO. FOR OMNI CALCULATIONS
    0.00                    !  ARRAY HEADING FROM NORTH (deg) [0,360]
!                   SHIPPING NOISE
       y                    !  COMPUTE SHIPPING NOISE? [y,n]
    0.00                    !  MINIMUM SHIP RANGE (m)
5000000.00                  !  MAXIMUM SHIP RANGE (m)
    6.00                    !  SHIP SOURCE DEPTH (m)
       1                    !  SHIP SOURCE LEVELS:  1=RANDI, 2=HITS III
   10.00                    !  PLOT SMOOTHING FACTOR WIDTH (deg) [0,360]
      40                    !  SHIP NUMBER OR RADIAL NUMBER TO SAVE [0=LAST]
!                    SHIPPING DATA
       y                    !  EXTRACT SHIPPING DATA?  y=HITS III, n=SHIPPING FILE
    5000                    !  MAXIMUM NUMBER OF SHIPS TO DETERMINE NOISE [1,5000]
 1234567                    !  RANDOM SEED NUMBER FOR SHIP EXTRACTIONS [LARGE ODD]
 !                   BEAMFORMING
       1                    !  BEAMFORMERS:  1=DFT, 2=FFT, 3=VOLUME DFT
      64                    !  NUMBER OF BEAMS [2,256]
       1                    !  SHADING:  1=HANN, 2=HAMMING, 3=UNIFORM, 4=BLACKWELL
!                   DEAD RECKONING
       0                    !  NUMBER OF DEAD RECKONINGS [0,9]
    1.00                    !  DEAD RECKONING INCREMENT (hours)
!                     WIND NOISE
       y                    !  COMPUTE WIND NOISE? [y,n]
       n                    !  EXTRACT WIND SPEED FROM HWS DATA BASE? [y,n]
   10.00                    !  USER DEFINED WIND SPEED (knots)
       y                    !  RUN KUPERMAN-INGENITO WIND MODEL? [y,n]
!                     FLOW NOISE
       n                    !  COMPUTE FLOW NOISE? [y,n]
    0.00                    !  SHIP TOW SPEED (knots) [5,18]
!                    SYSTEM NOISE
       n                    !  COMPUTE SYSTEM NOISE? [y,n]
    0.00                    !  SYSTEM NOISE POWER AT HYDROPHONE LEVEL (dB)
   49.50                    !  SYSTEM NOISE CORRELATION LENGTH (m)
!                   TOW SHIP NOISE
       n                    !  COMPUTE TOW SHIP NOISE? [y,n]
  145.41                    !  TOW SHIP NOISE SOURCE LEVEL (dB)
   20.00                    !  TOW SHIP ARRAY SET BACK DISTANCE (km)
 1000.00                    !  TOW SHIP DEPTH (m)
!                 ENVIRONMENTAL DATA
       u                    !  BOTTOM DATA BASE:  u=UNCLASSIFIED, c=CLASSIFIED
       u                    !  BATHYMETRY DATA BASE:  u=UNCLASSIFIED, c=CLASSIFIED
       0                    !  BLUG/HAMILTON BOTTOM:  0=NOT SELECTED, 1=SELECTED
       1                    !  SOUND SPEED DATA BASE:  1=HOP GDEM, 2=LEVITUS
       0                    !  RUN:  0=RANGE DEPENDENT, 1=RANGE INDEPENDENT
!                    PROPAGATION
       3                    !  0=FEPE, 1=SSPE, 2=FEPE RADIAL, 3=HIGH RESOLUTION
      72                    !  NUMBER OF RADIALS [FEPE RADIAL & HIGH RESOLUTION]
```

Figure 1: The RANDI 3.1 user input file for the example model run.

```
        y                                ! RADIAL SECTORS:  y=AUTOMATIC, n=USER DEFINED
        1                                ! NUMBER OF PADE TERMS [FEPE TYPES ONLY]
        1                                ! FEPE STARTER: 1=GAUSS,2=GREEN,3=MODE,4=IMAGE,5=USER
    22.50                                ! HALF BEAM WIDTH [SSPE & FEPE MODE STARTER]
 0.500000                                ! FEPE RANGE STEP FACTOR    [WAVELENGTH IF 0]
 0.250000                                ! FEPE DEPTH STEP FACTOR    [WAVELENGTH/2 IF 0]
   0.00      5.00      2.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   1
   5.00     10.00      7.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   2
  10.00     15.00     12.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   3
  15.00     20.00     17.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   4
  20.00     25.00     22.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   5
  25.00     30.00     27.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   6
  30.00     35.00     32.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   7
  35.00     40.00     37.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   8
  40.00     45.00     42.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.   9
  45.00     50.00     47.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  10
  50.00     55.00     52.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  11
  55.00     60.00     57.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  12
  60.00     65.00     62.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  13
  65.00     70.00     67.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  14
  70.00     75.00     72.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  15
  75.00     80.00     77.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  16
  80.00     85.00     82.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  17
  85.00     90.00     87.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  18
  90.00     95.00     92.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  19
  95.00    100.00     97.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  20
 100.00    105.00    102.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  21
 105.00    110.00    107.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  22
 110.00    115.00    112.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  23
 115.00    120.00    117.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  24
 120.00    125.00    122.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  25
 125.00    130.00    127.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  26
 130.00    135.00    132.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  27
 135.00    140.00    137.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  28
 140.00    145.00    142.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  29
 145.00    150.00    147.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  30
 150.00    155.00    152.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  31
 155.00    160.00    157.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  32
 160.00    165.00    162.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  33
 165.00    170.00    167.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  34
 170.00    175.00    172.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  35
 175.00    180.00    177.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  36
 180.00    185.00    182.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  37
 185.00    190.00    187.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  38
 190.00    195.00    192.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  39
 195.00    200.00    197.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  40
 200.00    205.00    202.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  41
 205.00    210.00    207.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  42
 210.00    215.00    212.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  43
 215.00    220.00    217.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  44
 220.00    225.00    222.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  45
 225.00    230.00    227.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  46
 230.00    235.00    232.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  47
 235.00    240.00    237.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  48
 240.00    245.00    242.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  49
 245.00    250.00    247.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  50
 250.00    255.00    252.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  51
 255.00    260.00    257.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  52
 260.00    265.00    262.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  53
 265.00    270.00    267.50              ! SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  54
```

Figure 1: (cont.).

```
270.00    275.00    272.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  55
275.00    280.00    277.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  56
280.00    285.00    282.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  57
285.00    290.00    287.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  58
290.00    295.00    292.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  59
295.00    300.00    297.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  60
300.00    305.00    302.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  61
305.00    310.00    307.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  62
310.00    315.00    312.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  63
315.00    320.00    317.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  64
320.00    325.00    322.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  65
325.00    330.00    327.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  66
330.00    335.00    332.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  67
335.00    340.00    337.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  68
340.00    345.00    342.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  69
345.00    350.00    347.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  70
350.00    355.00    352.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  71
355.00    360.00    357.50    !  SECTOR BEARINGS:  START, ENDING, RUN FOR RADIAL NO.  72
```

Figure 1: (cont.).

ships.dat

25.0000	60.3000					
8.53800	63.2980	270.200	15.0000	360.000	1856.65	169.600
12.1850	52.6170	270.300	13.0000	377.000	1636.65	210.900
5.97100	98.7090	303.700	13.0000	394.000	4598.69	110.800
25.7427	57.7517	291.100	12.0000	361.000	268.830	288.421
5.25400	91.6840	251.300	13.0000	383.000	3998.76	118.000
5.74700	79.5410	326.600	14.0000	424.000	2962.26	133.000
-12.8100	81.8680	162.200	13.0000	308.000	4807.87	148.500
5.24300	98.0050	303.600	15.0000	426.000	4575.74	112.300
5.48600	97.6910	303.600	14.0000	336.000	4531.93	112.300
7.90100	53.5780	71.2000	15.0000	459.000	2029.45	201.700
19.2720	65.7450	40.3000	10.00000	138.000	847.780	137.600
4.69000	69.7950	173.200	9.00000	74.0000	2473.92	154.300
17.8680	86.7940	197.300	14.0000	473.000	2847.05	100.9000
2.88600	77.3560	236.300	8.00000	96.0000	3061.08	140.700
5.09400	87.8910	90.1000	15.0000	311.000	3679.60	122.400
4.53900	99.9720	304.000	16.0000	409.000	4801.54	111.600
7.51500	54.2250	71.2000	14.0000	396.000	2047.17	199.400
12.6630	67.8460	332.700	10.00000	69.0000	1582.91	148.600
5.48500	98.7450	123.600	16.0000	479.000	4630.52	111.400
4.86800	81.9090	124.000	12.0000	362.000	3211.81	130.600
29.8860	49.3900	126.600	12.0000	366.000	1204.30	299.200
20.0930	59.5410	360.000	12.0000	324.000	550.769	188.300
12.6420	45.1340	109.200	13.0000	430.000	2101.29	232.000
12.9370	46.4910	270.300	14.0000	398.000	1972.53	229.700
6.72300	94.2030	109.400	10.00000	376.000	4133.72	113.600
7.25100	72.8000	269.800	11.0000	382.000	2377.41	143.900
7.03700	72.2080	11.6000	8.00000	54.0000	2363.20	145.600
5.77100	98.5050	303.600	14.0000	390.000	4591.15	111.200
25.5890	57.3530	111.000	14.0000	474.000	303.193	283.100
14.2340	42.1420	327.600	15.0000	376.000	2241.73	241.200
16.0520	83.7100	339.700	7.00000	136.000	2626.07	107.700
12.3170	45.6250	289.200	15.0000	426.000	2087.81	230.200
12.8450	55.5530	109.300	15.0000	354.000	1433.46	201.100
6.41700	95.2720	108.400	13.0000	438.000	4251.19	113.100
17.4640	67.5260	135.700	10.00000	336.000	1122.58	136.800
6.66000	94.6010	108.400	16.0000	491.000	4174.39	113.400
23.8020	36.6710	327.900	10.00000	342.000	2391.87	271.800
23.3130	37.7820	162.600	13.0000	325.000	2288.15	270.000
7.51500	78.5870	303.700	12.0000	426.000	2746.01	131.900
5.33500	87.8540	90.1000	14.0000	459.000	3659.32	122.100
6.51000	90.1160	89.8000	13.0000	314.000	3776.44	117.900
9.38900	54.6400	288.400	16.0000	403.000	1835.01	200.000
-11.1340	44.3780	118.300	8.00000	92.0000	4370.17	205.100
5.44700	83.5990	90.1000	13.0000	476.000	3298.65	127.300
17.8020	69.2650	332.600	8.00000	87.0000	1224.02	129.100
25.8470	35.1320	149.800	16.0000	495.000	2523.75	277.600
-14.9330	69.3860	43.4000	16.0000	402.000	4545.21	166.500
11.3570	91.9690	161.700	13.0000	487.000	3657.57	108.700
0.159000	47.7910	138.400	14.0000	327.000	3070.24	207.800
15.6890	89.9450	180.000	14.0000	321.000	3239.96	102.5000
12.1777	43.7755	327.300	15.0000	346.000	2244.99	233.615
18.0030	67.4260	111.000	10.00000	87.0000	1070.63	135.200

Figure 2: The shipping input file generated by RANDI 3.1 using the HITS database. This is a partial listing of the shipping information file (described in section 6.2) for this run. This file was created by setting the ship extraction flag to 'y' (described in section 4.4).

dr_ships.dat

```
 LAT     LON    HDG   VEL    LEN     RNG    BRG    SLV
DR #   0
    24.8810   61.6140    90.6000   13.0000   428.0000   133.1030    95.4000   166.094
    23.0720   65.6830   121.1000    9.0000    56.0000   586.7800   110.3000   137.345
    23.9390   63.8660   264.5000    8.0000   105.0000   379.3810   107.4000   139.906
    20.7620   69.5610   244.3000    8.0000   105.0000  1058.2300   114.6000   139.906
    21.2350   68.8720   212.5000   11.0000   397.0000   970.4730   113.8000   160.950
    21.4000   68.1280   212.4000   12.0000   335.0000   893.7210   115.0000   161.472
    22.0680   67.9280   212.3000   14.0000   378.0000   842.4180   111.2000   166.725
    22.3420   66.9080    70.8000   13.0000   282.0000   734.3240   112.4000   161.837
    22.3940   66.2620   188.5000    9.0000   113.0000   672.1020   114.3000   143.642
    19.8190   69.1950   254.6000    8.0000   110.0000  1079.4600   120.4000   140.328
    20.1400   69.2460   304.7000   13.0000   396.0000  1064.5800   118.7000   165.277
    20.4640   68.5860   197.7000   10.0000   386.0000   987.1500   119.0000   158.174
    21.4900   67.5950    68.3000    9.0000   132.0000   840.5350   116.2000   145.062
    21.9160   65.9530    64.8000    9.0000   137.0000   670.2970   119.6000   145.404
    22.4390   65.6700    77.8000   10.0000    68.0000   615.9220   116.4000   141.817
    22.2830   65.2860    90.6000   13.0000   329.0000   590.4780   119.7000   163.375
    22.5950   65.4020   270.6000   14.0000   364.0000   583.4620   116.2000   166.336
    22.8790   64.7400   117.3000    7.0000   110.0000   508.7710   116.7000   136.849
    22.8730   64.6260   106.2000   10.0000    85.0000   498.8870   117.4000   143.814
    22.9660   64.1170   110.6000   12.0000   279.0000   448.6250   119.5000   159.646
    23.1020   64.0780    90.6000   13.0000   281.0000   437.5300   118.0000   161.802
    18.5080   71.1200   251.2000   14.0000   341.0000  1328.5000   120.8000   165.669
    19.0790   70.1810    99.9000    8.0000   117.0000  1211.2100   120.9000   140.890
    21.1950   66.6850    90.5000   13.0000   303.0000   777.4200   121.7000   162.549
    21.0670   66.5690   270.5000   10.0000   382.0000   775.7230   123.0000   158.066
    21.1720   65.9100   290.3000   13.0000   376.0000   713.7860   125.4000   164.739
    23.9390   62.2130   110.7000   13.0000   280.0000   226.5970   121.0000   161.767
    13.8630   73.7190   341.9000   10.0000   277.0000  1870.6700   128.9000   154.824
    14.4870   73.7630   180.0000   11.0000   366.0000  1827.1600   127.2000   160.108
    14.9450   73.8870   360.0000   11.0000   325.0000  1803.7000   125.7000   158.899
    14.9250   73.0030   180.0000   14.0000   437.0000  1733.9100   127.8000   168.246
    15.3250   73.2320   198.1000   14.0000   277.0000  1722.9301   126.2000   163.592
    15.3480   72.5700   180.0000   12.0000   363.0000  1667.9000   127.7000   162.291
    15.9070   71.2970   136.1000    9.0000   131.0000  1525.5500   129.4000   144.993
    16.2990   70.8240   284.5000    9.0000   105.0000  1458.9800   129.5000   142.975
    16.5210   70.9960     6.7000    8.0000   149.0000  1455.6899   128.3000   143.110
    16.8250   71.0440   270.4000   13.0000   469.0000  1437.1400   127.1000   167.073
    16.3880   70.4580   289.6000   16.0000   489.0000  1423.8600   130.3000   172.937
    16.4130   70.3940   152.9000    8.0000    56.0000  1417.0300   130.4000   134.276
    17.7570   70.4430   270.5000   14.0000   345.0000  1321.6400   125.5000   165.788
    17.9160   69.8850   270.5000   14.0000   288.0000  1264.9000   126.6000   163.976
    17.8630   69.7610    90.5000   15.0000   491.0000  1258.8101   127.2000   171.300
    17.6670   69.5180   270.5000   15.0000   451.0000  1253.8800   128.7000   170.381
    17.8020   69.2650   332.6000    8.0000    87.0000  1224.0200   129.1000   138.208
    17.8770   69.3140   270.5000   15.0000   465.0000  1222.2500   128.6000   170.710
    17.8650   68.8880   305.6000   11.0000   378.0000  1189.9700   130.1000   160.441
    18.8460   69.0440   251.1000   13.0000   488.0000  1130.8000   125.5000   167.504
    19.1520   68.3300   185.2000   10.0000    96.0000  1051.1700   126.6000   144.910
    19.7100   66.9380   147.3000   16.0000   432.0000   900.2320   129.4000   171.603
    20.3630   66.9190   342.3000   16.0000   464.0000   851.7960   125.9000   172.368
    20.4010   66.0470   342.3000   15.0000   405.0000   779.6340   129.8000   169.241
```

Figure 3: A partial listing of the dr_ships.dat.file (described in section 6.5). This file contains a list of the ships processed during model execution.

main.out

```
   50.0000  0.  64  64  2602  0     978.000
 0  1     25.0000    60.3000
 0.
  0.0  14.4  20.4  25.0  29.0  32.5  35.7  38.6  41.4  44.0
 46.6  49.0  51.3  53.6  55.8  57.9  60.0  62.0  64.1  66.0
 68.0  69.9  71.8  73.7  75.5  77.4  79.2  81.0  82.8  84.6
 86.4  88.2  90.0  91.8  93.6  95.4  97.2  99.0 100.8 102.6
104.5 106.3 108.2 110.1 112.0 114.0 115.9 118.0 120.0 122.1
124.2 126.4 128.7 131.0 133.4 136.0 138.6 141.4 144.3 147.5
151.0 155.0 159.6 165.6 180.0
 1
   27.5910      35.9812      38.6786      38.9436      39.0899      39.5613      40.1756
   40.8403      41.2946      41.9485      42.1582      42.5736      43.1581      42.8941
   42.9672      43.4463      43.3613      42.9248      42.9806      43.5278      43.9102
   43.8526      43.4981      43.2095      43.2156      43.3394      43.6668      43.9651
   43.8274      43.9346      44.6122      45.1289      45.1992      45.1269      44.6122
   43.9346      43.8274      43.9651      43.6668      43.3394      43.2156      43.2095
   43.4981      43.8526      43.9102      43.5278      42.9806      42.9248      43.3613
   43.4463      42.9672      42.8941      43.1581      42.5736      42.1582      41.9485
   41.2946      40.8403      40.1756      39.5613      39.0899      38.9436      38.6786
   35.9812      27.5910
   55.2694      58.4063      58.8928      56.2461      51.4732      50.3466      51.9169
   52.3379      52.5139      55.1233      56.3785      55.8418      54.2985      53.4061
   53.9620      54.8227      55.3341      55.0592      53.9740      51.2486      50.7623
   51.9975      54.1963      60.1665      64.6234      65.9068      67.0764      68.9519
   68.5232      75.2481      79.5344      76.1851      70.0879      77.2818      77.3196
   69.7782      64.0239      68.3302      71.1023      70.6809      66.2408      63.9772
   70.5173      76.6392      77.4736      72.6356      67.5814      73.3251      75.9513
   73.7787      66.2377      64.3754      70.1988      72.7655      73.0415      75.7033
   83.1347      82.7624      89.6014      93.5389      89.7493      77.1280      70.4899
   70.2662      66.2593
   92.5661  0   10.00000  0     92.4847
 2
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0         62.8          0.0          0.0          0.0          0.0          0.0
       0.0          0.0          0.0          0.0          0.0          0.0         19.9          0.0          0.0         15.5
      24.2         19.9          0.0         17.9         18.7         43.8         22.7         40.5         40.9         42.7
      50.4         44.3         39.8          0.0         46.8         37.1         34.6         29.2         37.7         36.4
      67.2         62.5         59.1         68.0         65.2         63.4         61.3         66.6         59.4         59.1
      62.9         63.5         69.4         57.3         65.7         44.0         47.6         51.4         46.9         38.6
      54.3         42.0         40.5         37.7         39.3         51.4         45.9         42.7         44.7         47.5
      46.1         46.2         58.1         55.2         52.7         49.0         50.7         62.9         52.0         52.9
      33.6         45.5         42.5         51.1         44.5         44.7         42.3         47.7         38.0         46.2
      52.3         49.6         47.2         53.9         50.9         61.0         66.3         62.6         48.6         54.3
      52.3          0.0          0.0         58.5         59.2          0.0   [illegible]         50.7          0.0          0.0
       0.0         48.5          0.0         52.3          0.0          0.0          0.0          0.0         79.0          0.0
       0.0          0.0          0.0         28.1          0.0          0.0          0.0          0.0          0.0         69.4
       0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
       0.0          0.0         50.5          0.0          0.0          0.0          0.0         69.7          0.0          0.0
      40.8         37.0          0.0          0.0          0.0          0.0         63.7          0.0          0.0         53.2
       0.0         29.6          0.0          0.0          0.0         61.8         60.8         61.7         58.3          0.0
      51.9          0.0          0.0         48.7          0.0          0.0         77.6          0.0          0.0          0.0
```

Figure 4: The main.out file for the example model run (described in section 6.1).

0.0	64.5	62.6	80.4	0.0	58.3	0.0	69.2	66.8	63.8
64.1	0.0	61.8	57.0	60.9	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.4	50.6	51.0	51.5	52.0	52.6	53.1
53.6	54.0	54.2	54.4	54.5	54.4	54.2	54.0	53.6	53.1
52.6	52.0	51.5	51.0	50.6	50.4	50.2	50.3	50.3	50.3
50.3	50.4	50.5	50.5	50.6	50.7	50.8	50.9	51.0	51.3
51.9	52.8	54.1	55.5	56.8	58.1	59.3	60.4	61.3	62.0
62.6	63.1	63.6	63.9	64.1	64.3	64.4	64.4	64.4	64.2
64.1	63.8	63.5	63.1	62.6	62.0	61.3	60.5	59.5	58.4
57.2	55.9	54.6	53.5	52.9	52.7	52.9	53.2	53.7	54.2
54.7	55.1	55.5	55.9	56.1	56.2	56.2	56.2	56.0	55.7
55.4	55.0	54.5	54.0	53.6	53.4	53.6	54.1	54.9	55.8
56.7	57.5	58.2	58.7	59.1	59.3	59.5	59.5	59.4	59.2
58.9	58.4	57.9	57.3	56.7	56.0	55.4	56.3	58.2	60.3
62.2	63.9	65.2	66.3	67.2	67.8	68.3	68.6	68.6	68.6
68.3	67.9	67.3	66.6	65.7	64.6	63.5	62.2	61.0	60.1
59.4	59.2	58.8	58.2	57.5	56.6	55.7	55.0	54.8	55.2
55.9	56.9	57.8	58.5	59.1	59.5	59.8	59.9	59.9	59.8
59.5	59.2	58.7	58.2	57.6	57.1	56.6	56.3	56.2	56.3
56.6	56.9	57.1	57.3	57.5	58.2	59.3	60.7	62.0	63.3
64.4	65.3	66.3	67.2	68.0	68.7	69.4	70.0	70.4	70.8
71.0	71.2	71.2	71.1	70.9	70.6	70.2	69.6	68.9	68.0
67.0	65.7	64.3	62.7	61.1	59.5	58.4	57.1	55.8	54.5
53.3	52.3	51.5	50.9	50.5	50.3	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2

92.5661 0.0000 10.0000 92.4847 58.1911

3

50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.4	50.6	51.0	51.5	52.0	52.6	53.1
53.6	54.0	54.2	54.4	54.5	54.4	54.2	54.0	53.6	53.1
52.6	52.0	51.5	51.0	50.6	50.4	50.2	50.3	50.3	50.3
50.3	50.4	50.5	50.5	50.6	50.7	50.8	50.9	51.0	51.3
51.9	52.8	54.1	55.5	56.8	58.1	59.3	60.4	61.3	62.0

Figure 4: (cont.).

51.9	52.8	54.1	55.5	56.8	58.1	59.3	60.4	61.3	62.0
62.6	63.1	63.6	63.9	64.1	64.3	64.4	64.4	64.4	64.2
64.1	63.8	63.5	63.1	62.6	62.0	61.3	60.5	59.5	58.4
57.2	55.9	54.6	53.5	52.9	52.7	52.9	53.2	53.7	54.2
54.7	55.1	55.5	55.9	56.1	56.2	56.2	56.2	56.0	55.7
55.4	55.0	54.5	54.0	53.6	53.4	53.6	54.1	54.9	55.8
56.7	57.5	58.2	58.7	59.1	59.3	59.5	59.5	59.4	59.2
58.9	58.4	57.9	57.3	56.7	56.0	55.4	56.3	58.2	60.3
62.2	63.9	65.2	66.3	67.2	67.8	68.3	68.6	68.6	68.6
68.3	67.9	67.3	66.6	65.7	64.6	63.5	62.2	61.0	60.1
59.4	59.2	58.8	58.2	57.5	56.6	55.7	55.0	54.8	55.2
55.9	56.9	57.8	58.5	59.1	59.5	59.8	59.9	59.9	59.6
59.5	59.2	58.7	58.2	57.6	57.1	56.6	56.3	56.2	56.3
56.6	56.9	57.1	57.3	57.5	58.2	59.3	60.7	62.0	63.3
64.4	65.3	66.3	67.2	68.0	68.7	69.4	70.0	70.4	70.6
71.0	71.2	71.2	71.1	70.9	70.6	70.2	69.6	68.9	68.0
67.0	65.7	64.3	62.7	61.1	59.5	58.4	57.1	55.8	54.5
53.3	52.3	51.5	50.9	50.5	50.3	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2

Figure 4: (cont.).

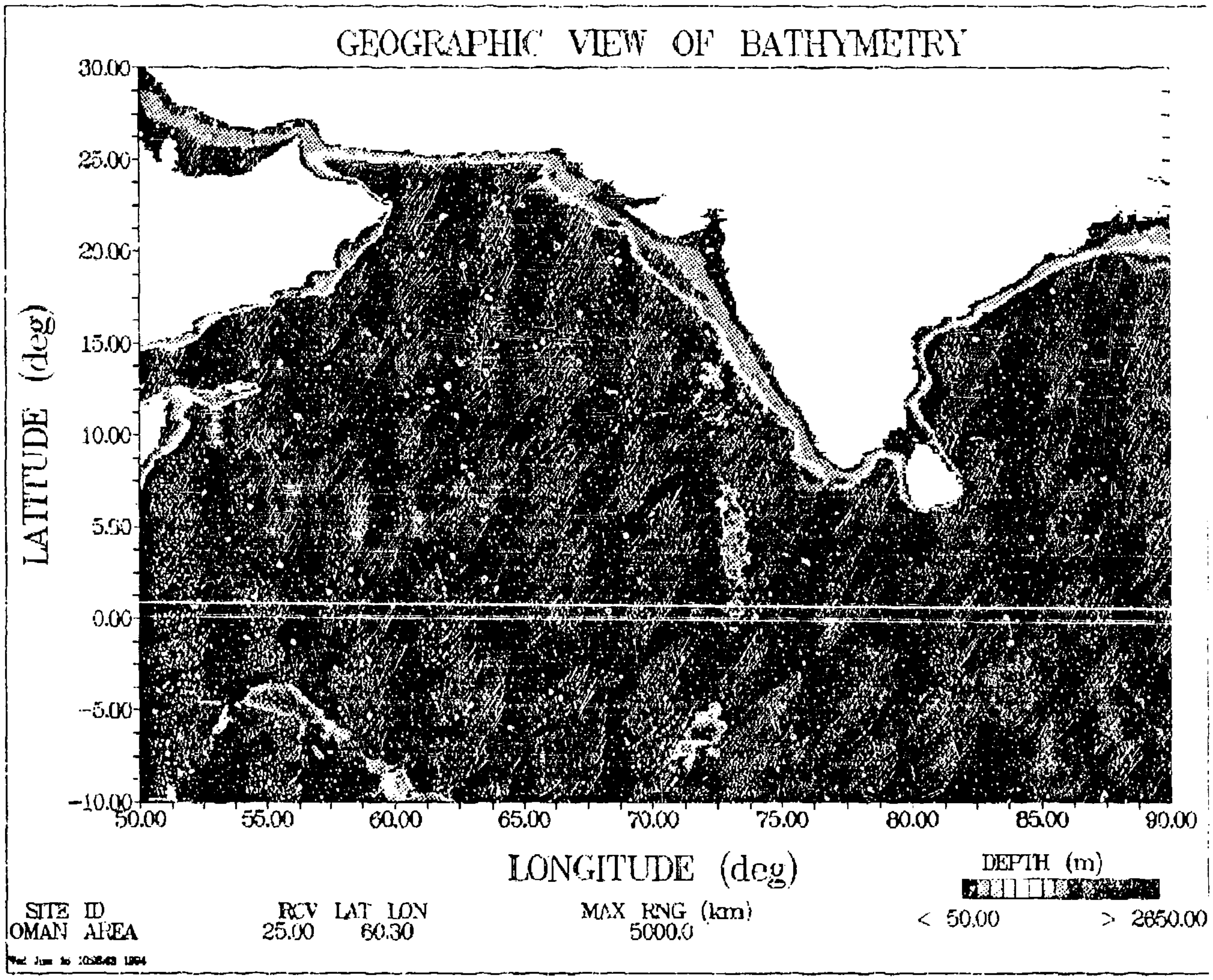


Figure 5: Example geographic view of bathymetry plot. The unclassified bathymetry for the area of this run was extracted at an extraction increment of .083333 (1/12 degree) by areadb.x (section 7.1). The output was then plotted by bathyplt.x (section 7.2).

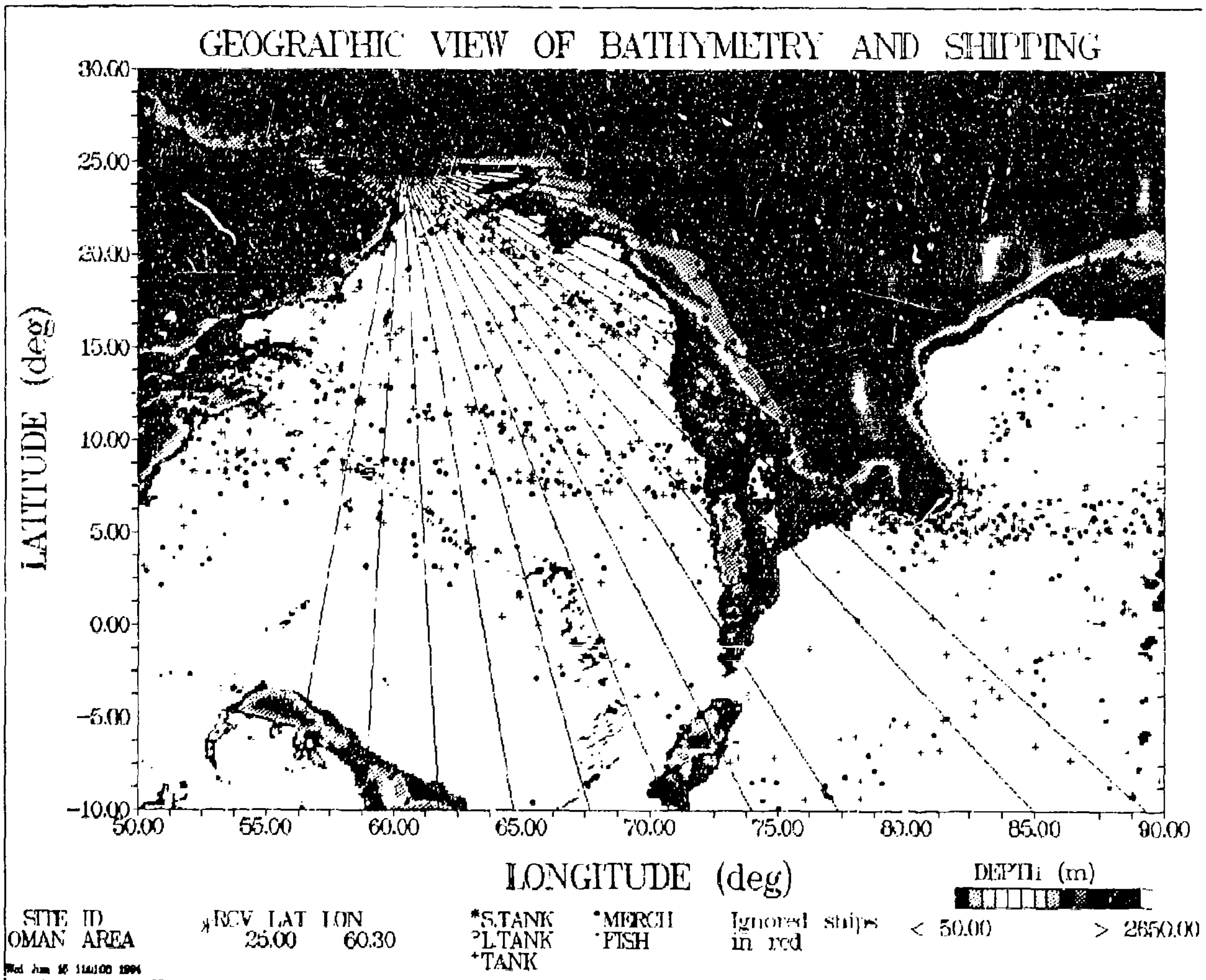


Figure 6: Example geographic view of bathymetry and shipping plot. The unclassified bathymetry for the area of this run was extracted by areadb.x (section 7.1). The plot which displays shallow water bathymetry contours, radial great circle paths, and the extracted and processed ships is created by the bathygep.x program (section 7.3).

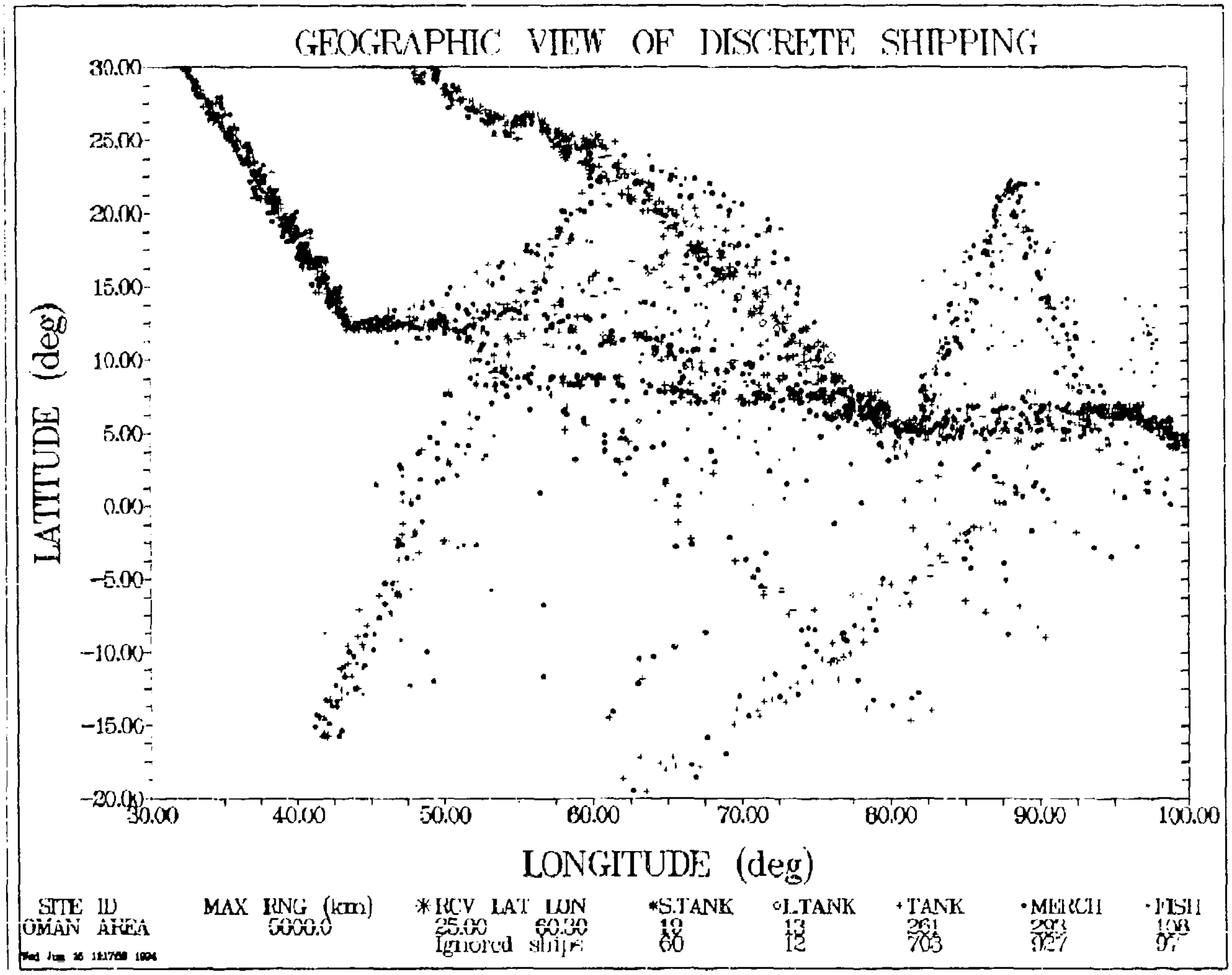


Figure 7: Example geographic view of discrete shipping plot. The ships in ships.dat (see Figure 2) are plotted by hitsplt.x (section 7.4). The ships pictured here are the extracted ships. The processed ships are black.

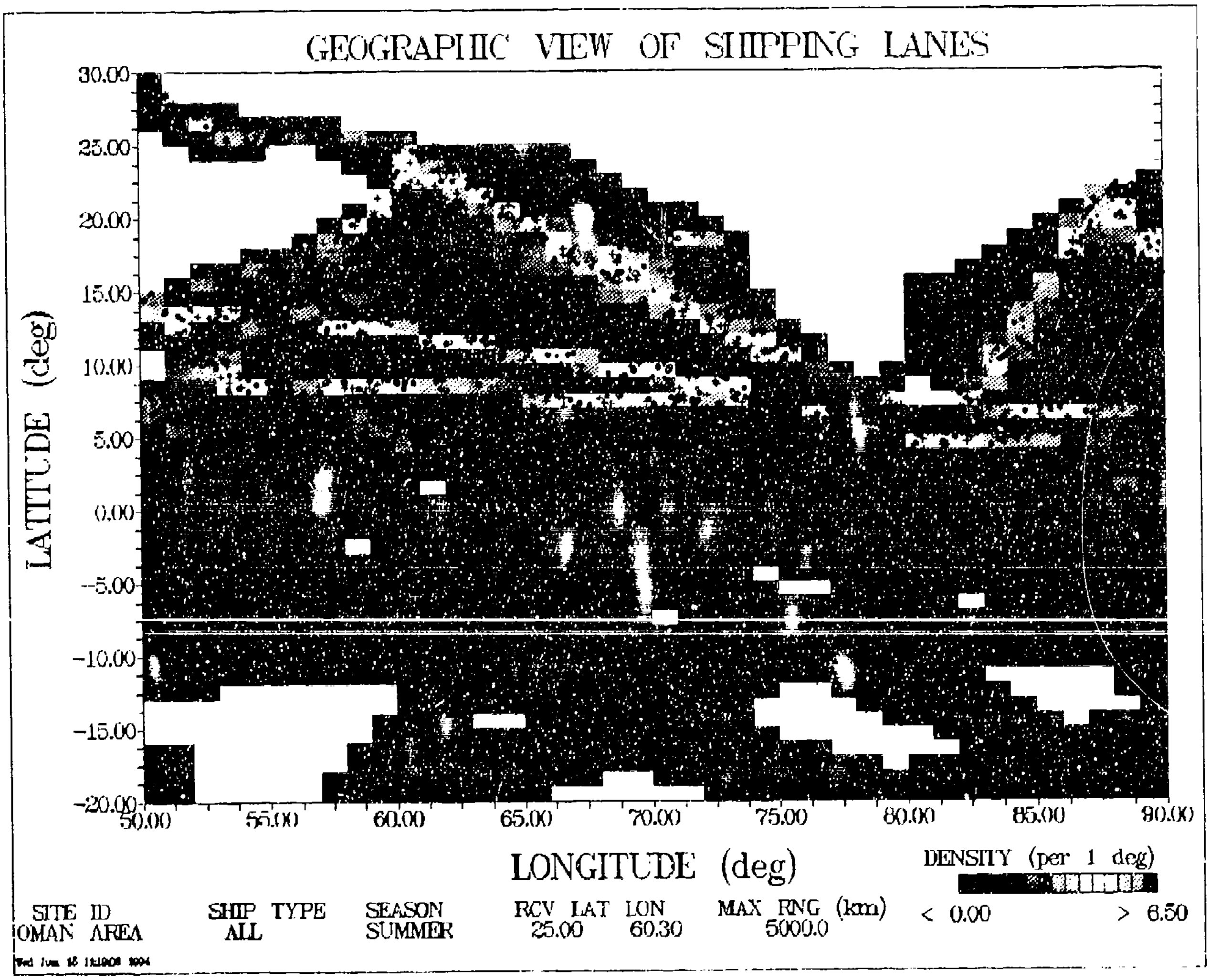


Figure 8: Example geographic view of shipping lanes plot. The shipping densities were extracted and plotted for the area of this run, and the ships in ships.dat (see Figure 2) were overlayed using shipden.x (section 7.5).

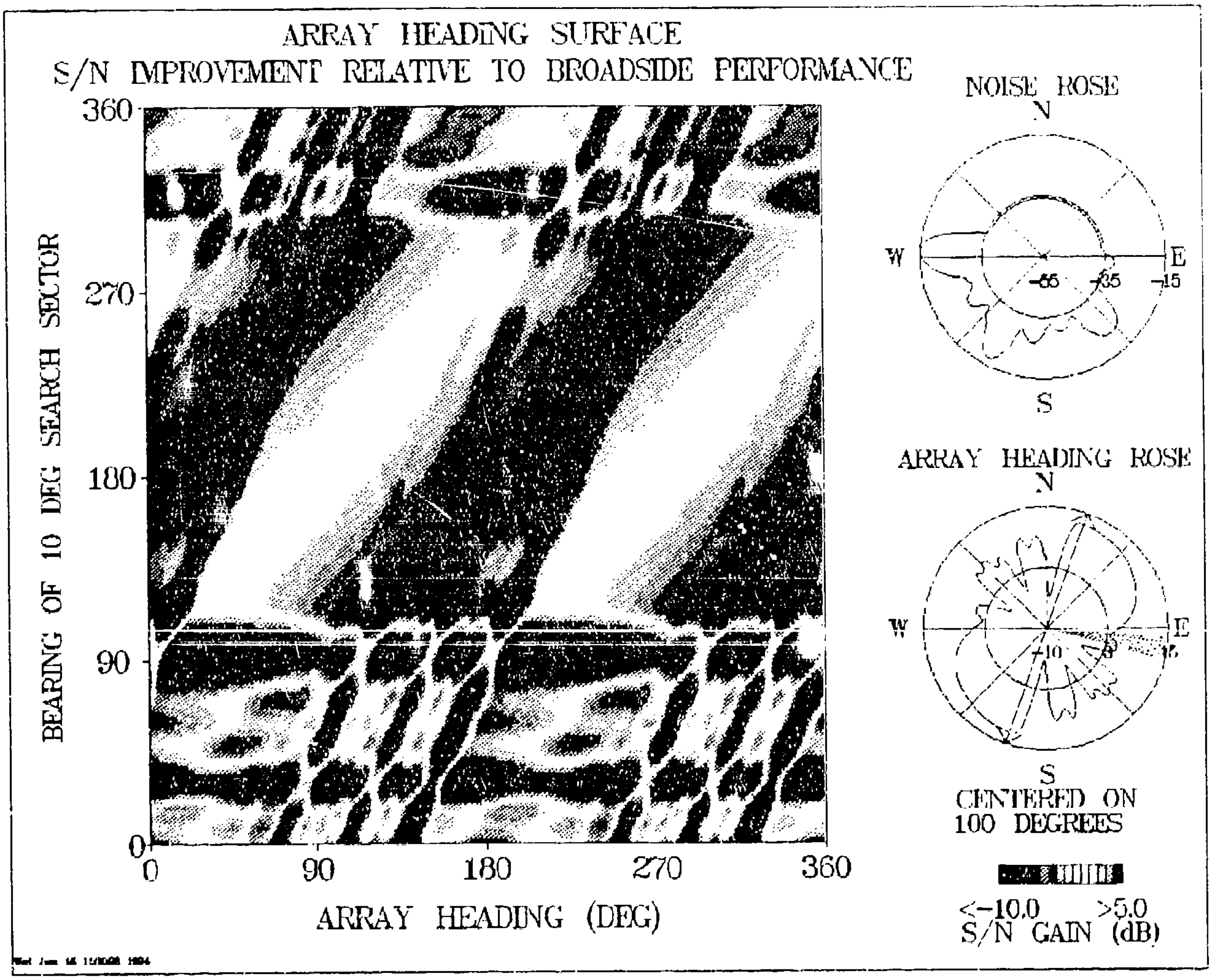


Figure 9: Example array heading surface plot. This information was plotted by ahs.x (section 7.6).

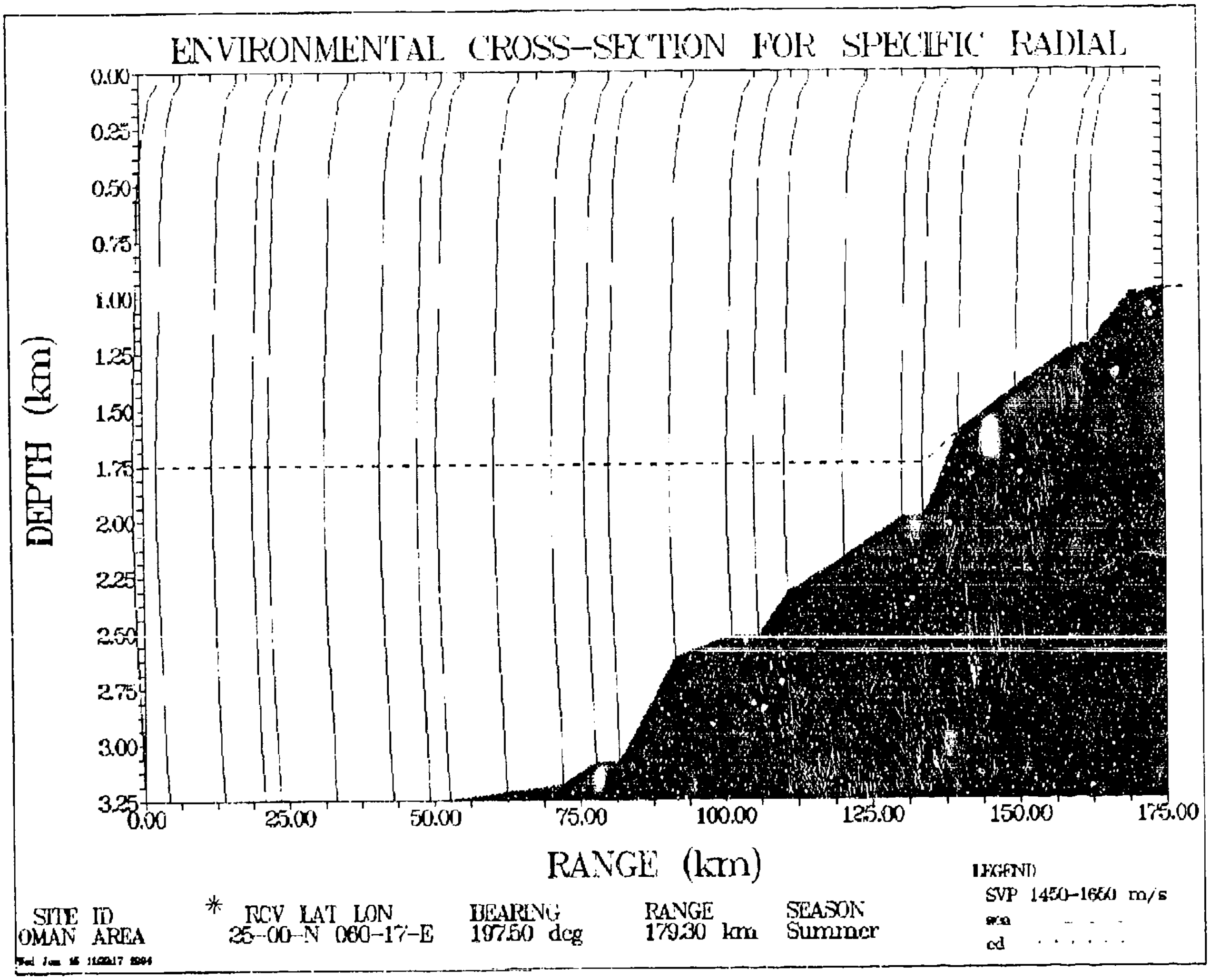


Figure 10: Example environment plot. Radial number 40 was selected and the sound speed and bathymetry of the environmental track was plotted by envplt.x (section 7.7).

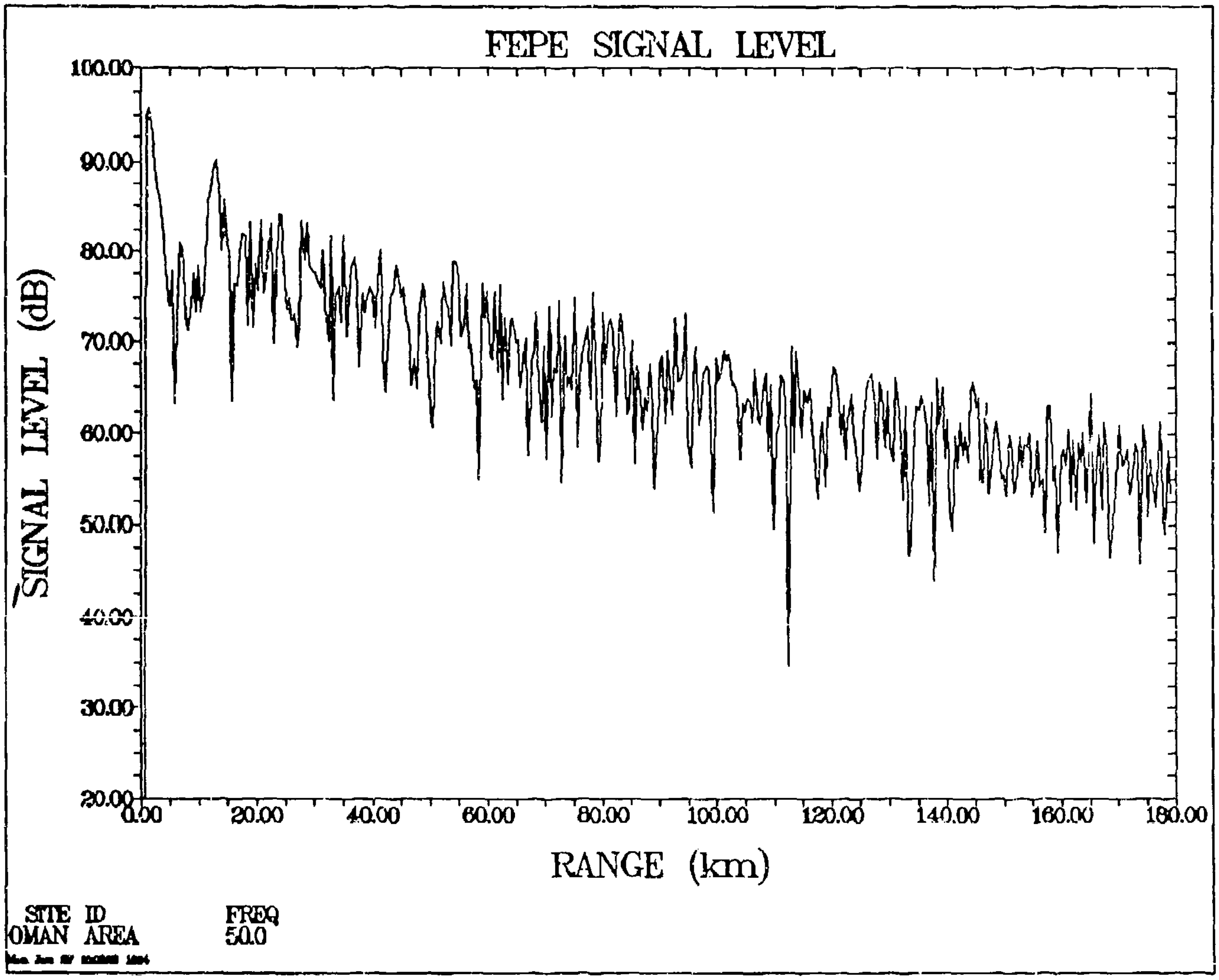


Figure 11: Example transmission loss / signal level curve plot. Since the high resolution radial option (pe option flag described in section 4.2) was used in this run (see Figure 1), a signal level vs range curve was plotted by tlplt.x. (section 7.8). This information was saved for the one radial only.

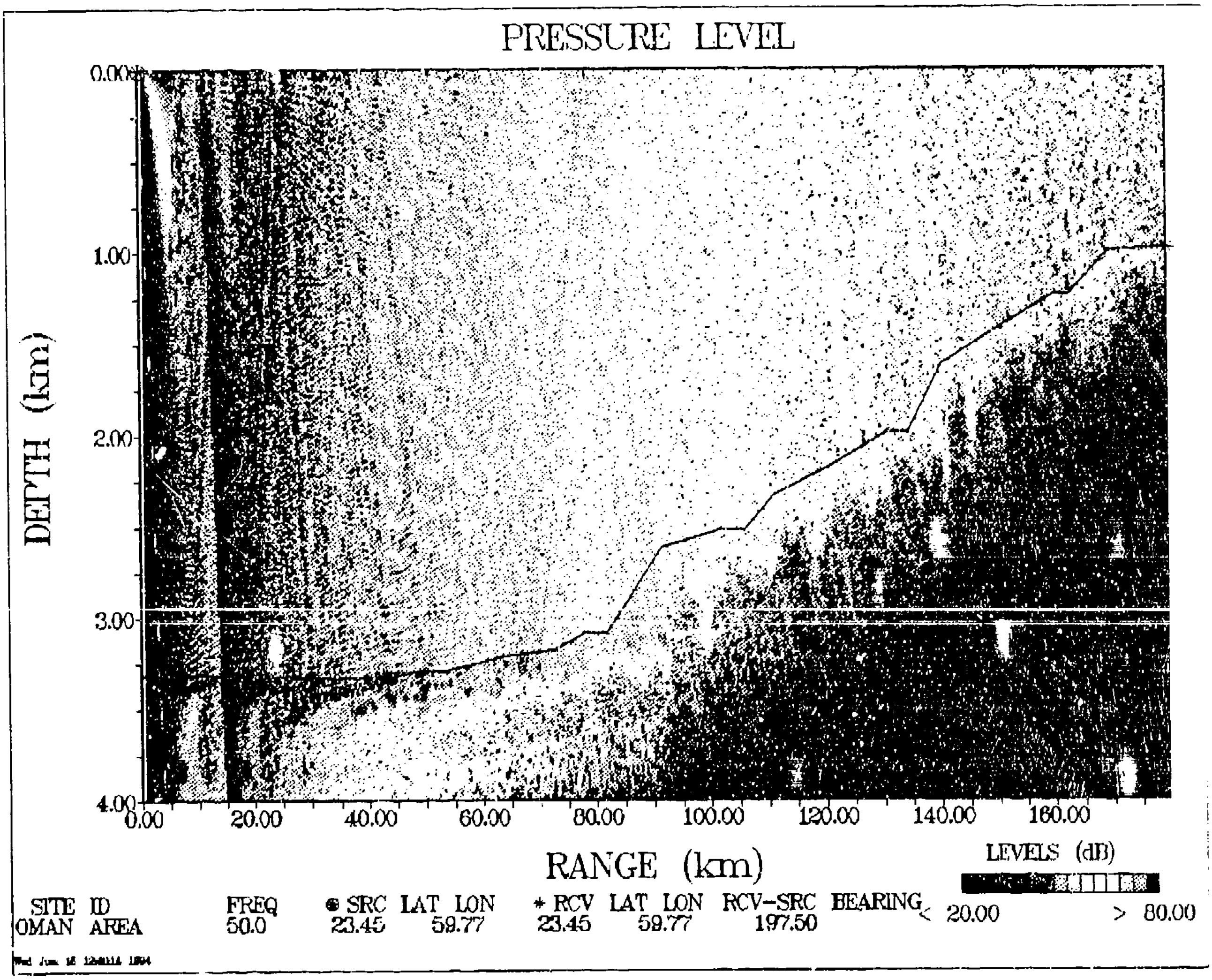


Figure 12: Example transmission loss / signal level field plot. Since the high resolution radial option (pe option flag described in section 4.2) was used in this run (see Figure 1), the signal level plotted on a depth vs range color field plot was plotted by fldplt.x (section 7.9). This information was saved for the one radial only.

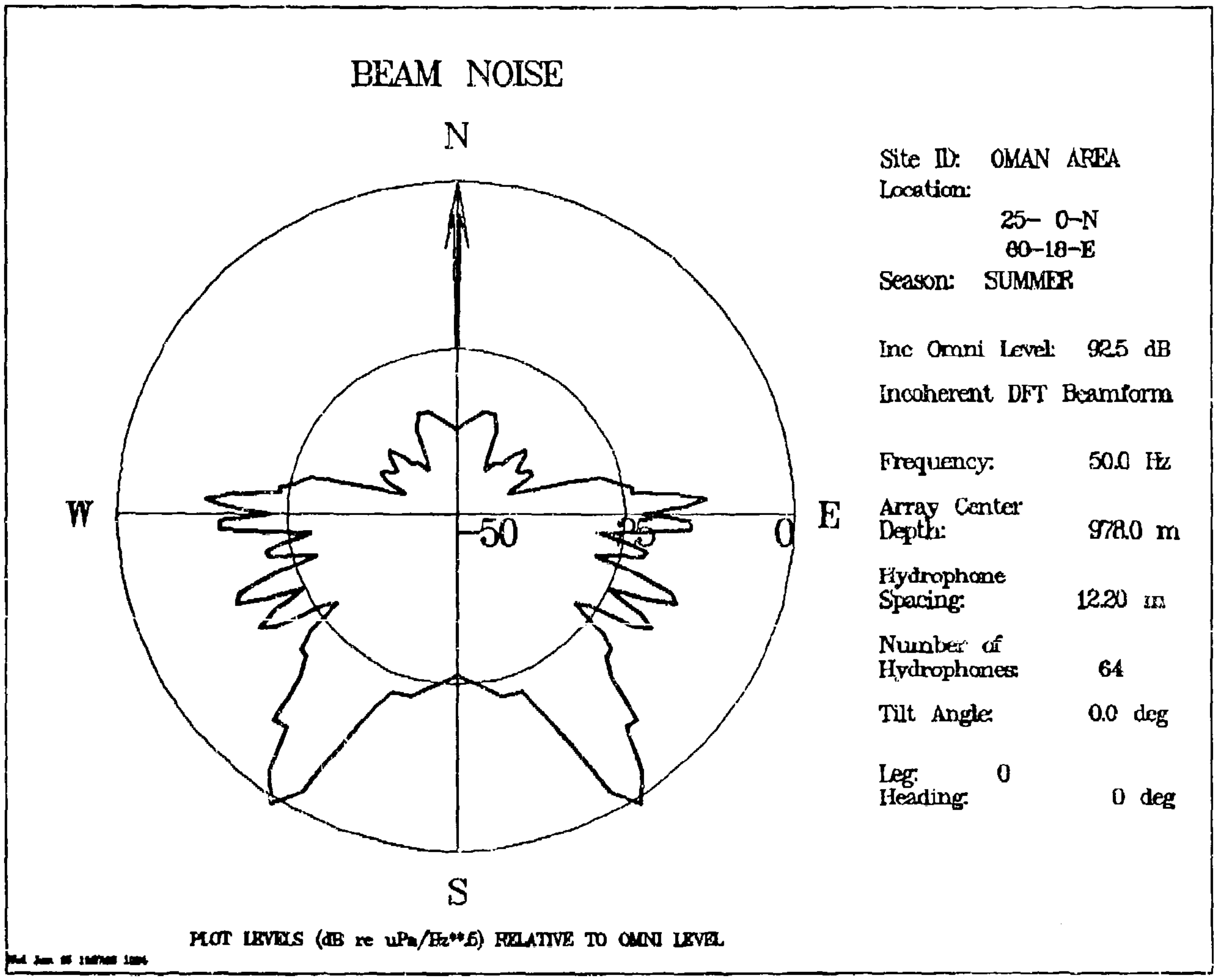


Figure 13: Example beam noise plot. The beam noise information was plotted by mainplot.x (section 7.10).

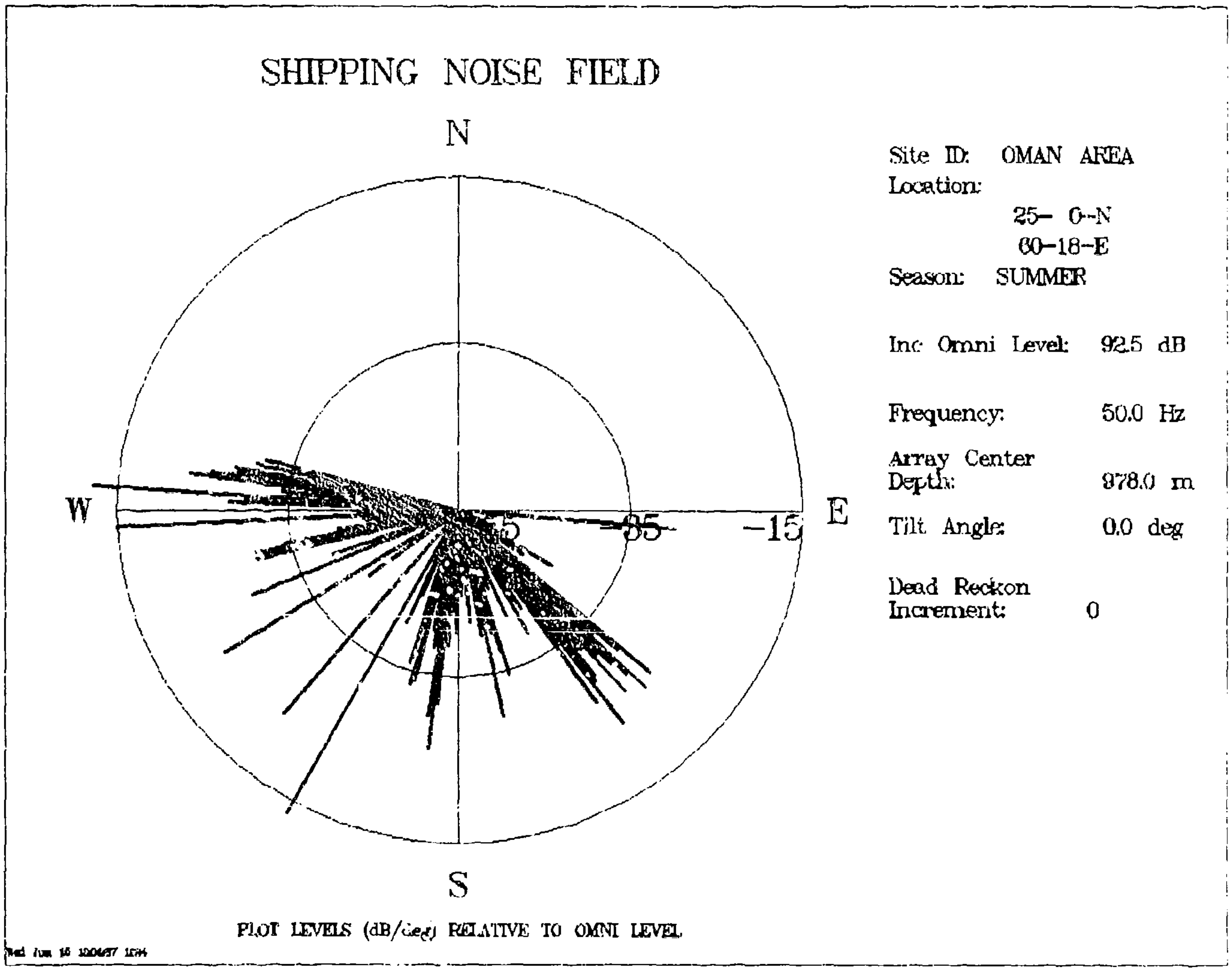


Figure 14: Example shipping noise field spike plot. The horizontal directionality information was plotted by mainplot.x (section 7.10).

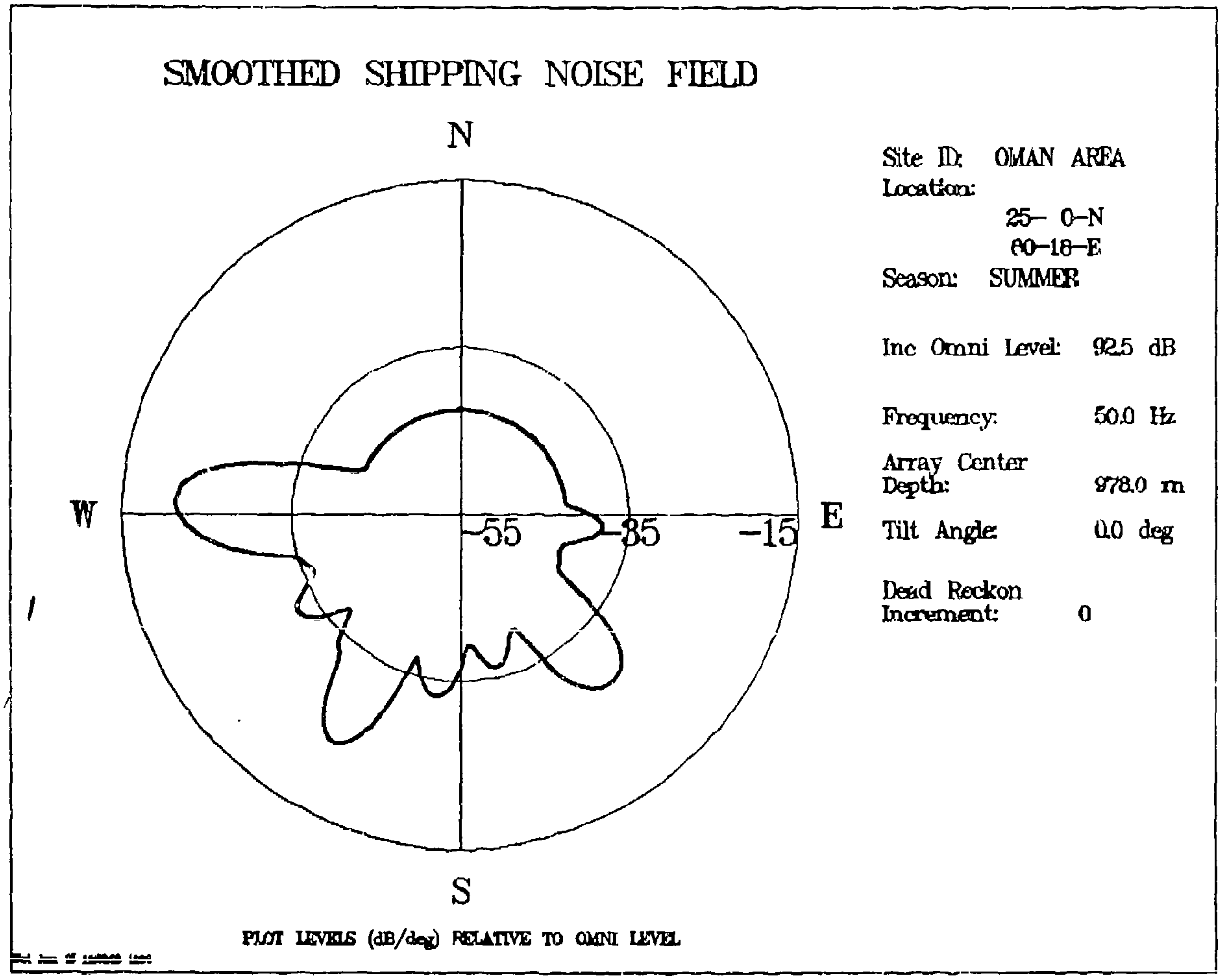


Figure 15: Example smoothed shipping noise field plot. The smoothed horizontal directionality was plotted by mainplot.x (section 7.10).

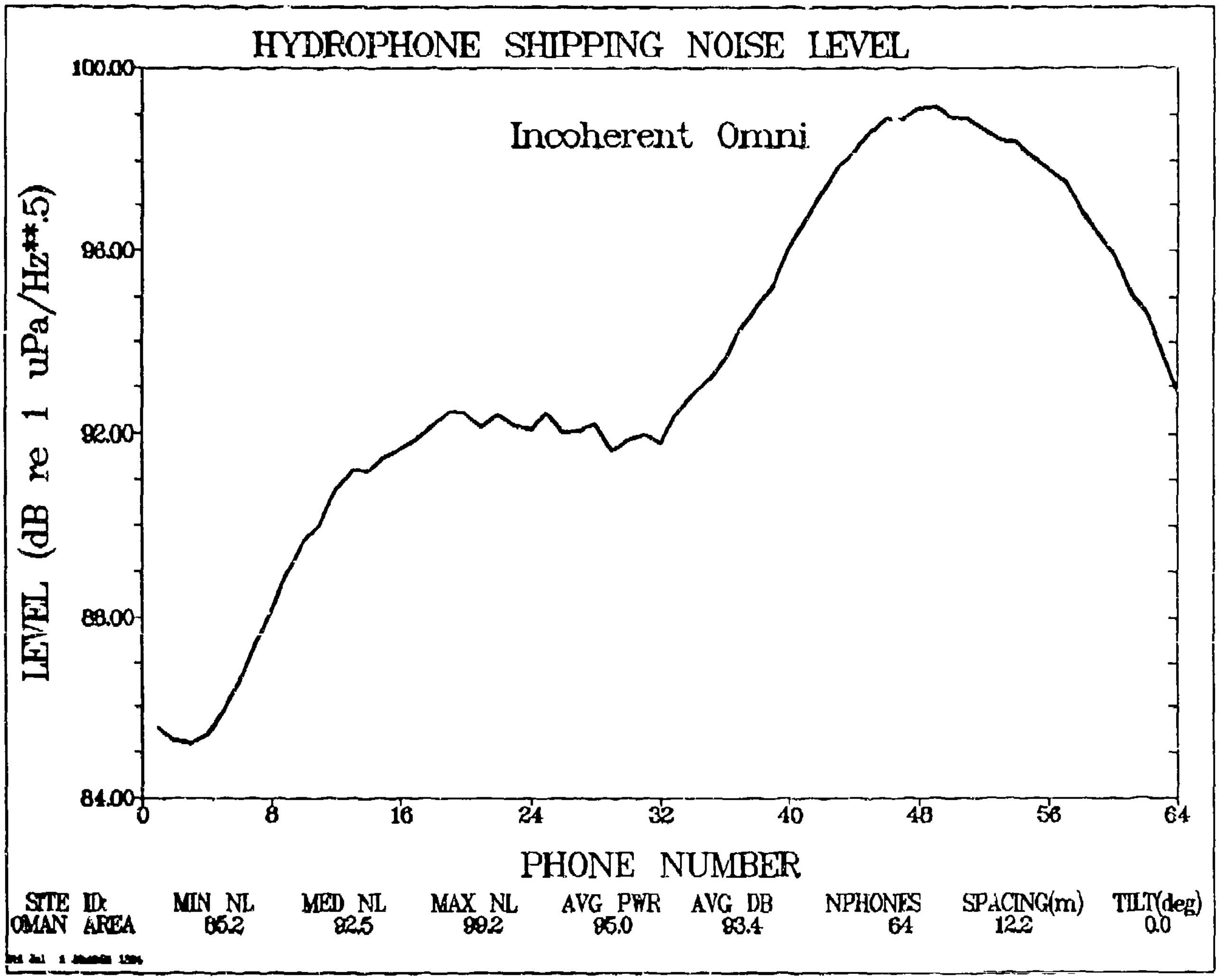


Figure 16: Example omni level vs hydrophone curve plot. This curve was plotted by omni_ship.x (section 7.11).

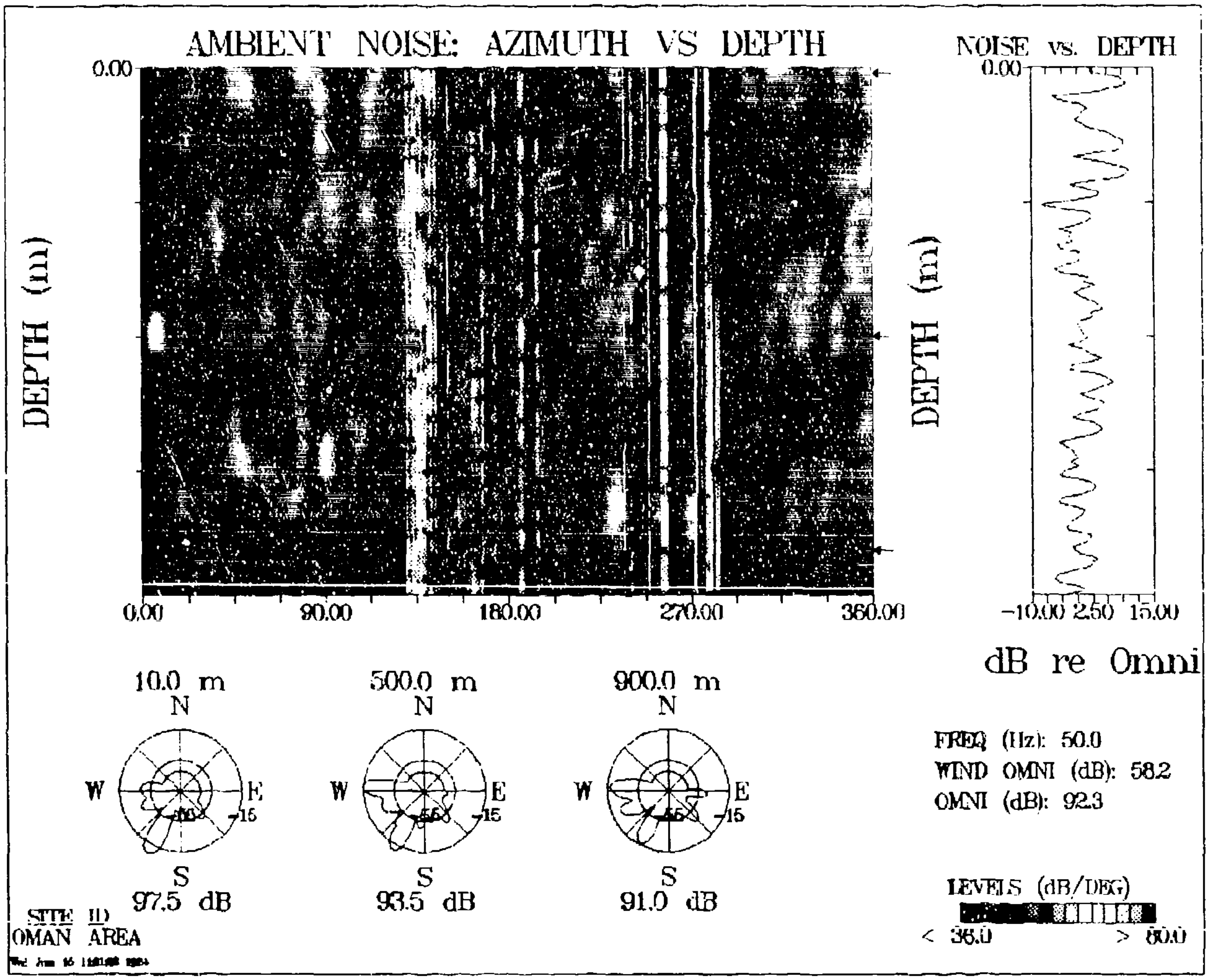


Figure 17: Example 3-d ambient noise field plot. This information was plotted by dirplt.x (section 7.12)

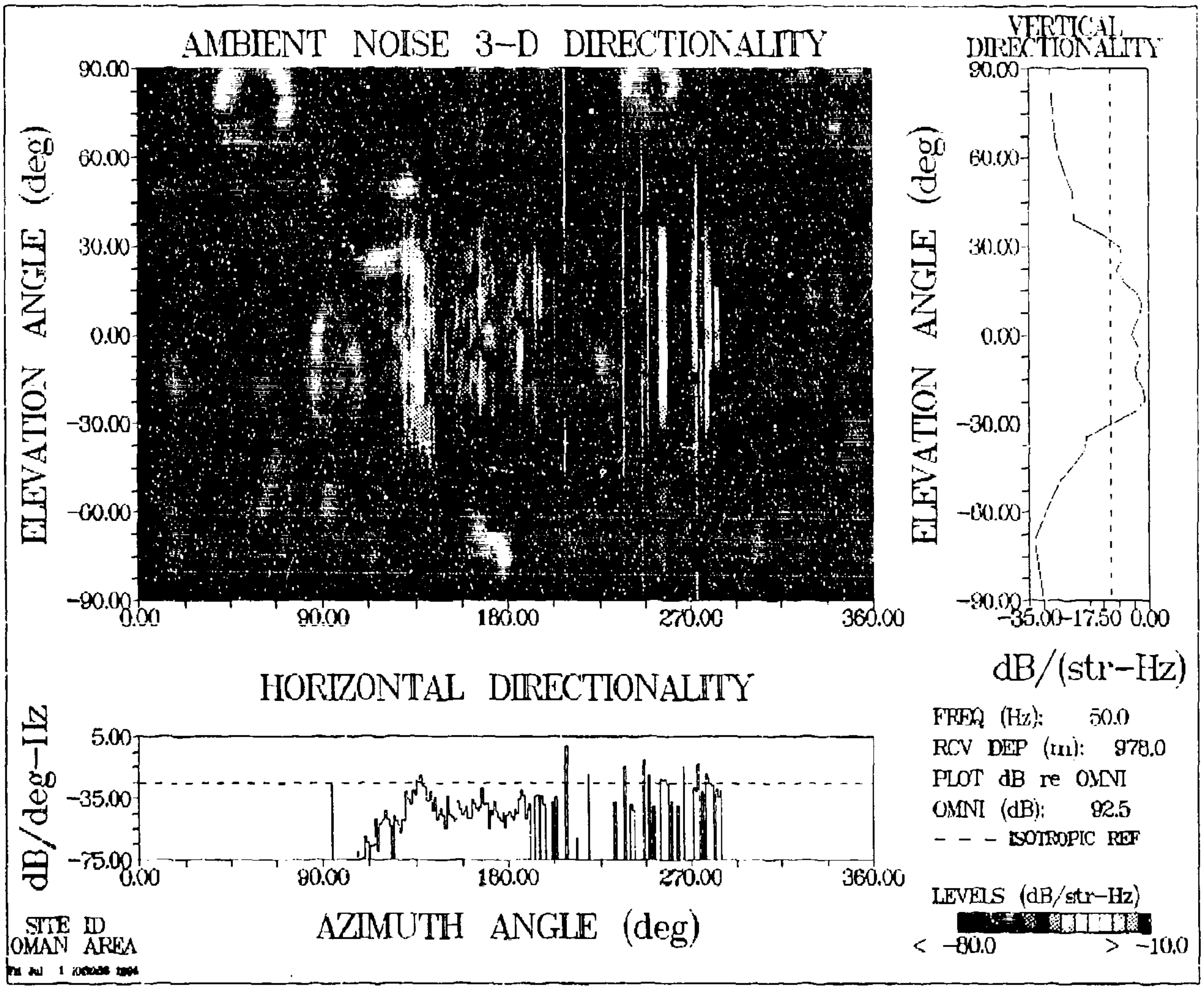


Figure 18: Example ambient noise 3-d directionality plot. For vertical directionality (section 7.13), a discrete Fourier transform was used and the center of the array is 738 m depth. The array consisted of 64 hydrophones spaced 7.5 m apart. RANDI 3.1 was not rerun for this case, vert_dir_dft.x (section 7.13) was used. The vertical directionality for this run was plotted by vertfld.x (section 7.14).

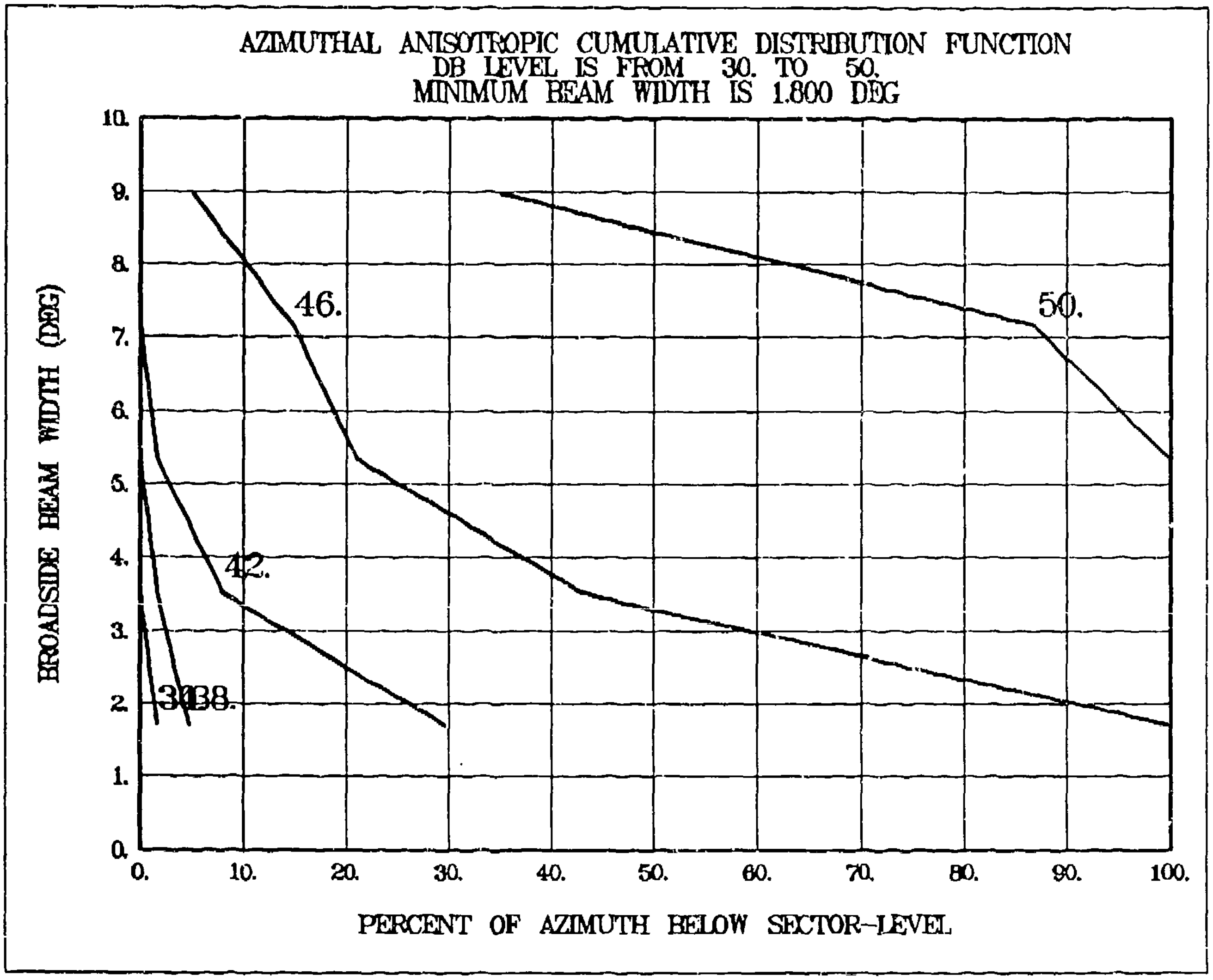


Figure 19: Example azimuthal anisotropic cumulative distribution function plot. The function was plotted by aacdf.x (section 7.15).

volcoord

```
64
 978.000
1
 -384.300  0.  0.
 -372.100  0.  0.
 -359.900  0.  0.
 -347.700  0.  0.
 -335.500  0.  0.
 -323.300  0.  0.
 -311.100  0.  0.
 -298.900  0.  0.
 -286.700  0.  0.
 -274.500  0.  0.
 -262.300  0.  0.
 -250.100  0.  0.
 -237.900  0.  0.
 -225.700  0.  0.
 -213.500  0.  0.
 -201.300  0.  0.
 -189.100  0.  0.
 -176.900  0.  0.
 -164.700  0.  0.
 -152.500  0.  0.
 -140.300  0.  0.
 -128.100  0.  0.
 -115.900  0.  0.
-103.7000  0.  0.
 -91.5000  0.  0.
 -79.3000  0.  0.
 -67.1000  0.  0.
 -54.9000  0.  0.
 -42.7000  0.  0.
 -30.5000  0.  0.
 -18.3000  0.  0.
 -6.10000  0.  0.
  6.10000  0.  0.
  18.3000  0.  0.
  30.5000  0.  0.
  42.7000  0.  0.
  54.9000  0.  0.
  67.1000  0.  0.
  79.3000  0.  0.
  91.5000  0.  0.
 103.7000  0.  0.
  115.900  0.  0.
  128.100  0.  0.
  140.300  0.  0.
  152.500  0.  0.
  164.700  0.  0.
  176.900  0.  0.
  189.100  0.  0.
  201.300  0.  0.
  213.500  0.  0.
  225.700  0.  0.
  237.900  0.  0.
  250.100  0.  0.
  262.300  0.  0.
  274.500  0.  0.
  286.700  0.  0.
  298.900  0.  0.
  311.100  0.  0.
  323.300  0.  0.
  335.500  0.  0.
  347.700  0.  0.
  359.900  0.  0.
  372.100  0.  0.
  384.300  0.  0.
```

Figure 20: Example volumetric array input file. A volumetric array containing 4 elements on the x axis, 3 elements on the y axis, and 2 elements on the z axis, a total of 24 hydrophones, is defined in this file. A volumetric beamformer was used. RANDI 3.1 was rerun for this case. See section 4.10 for more information on this file and volumetric arrays.

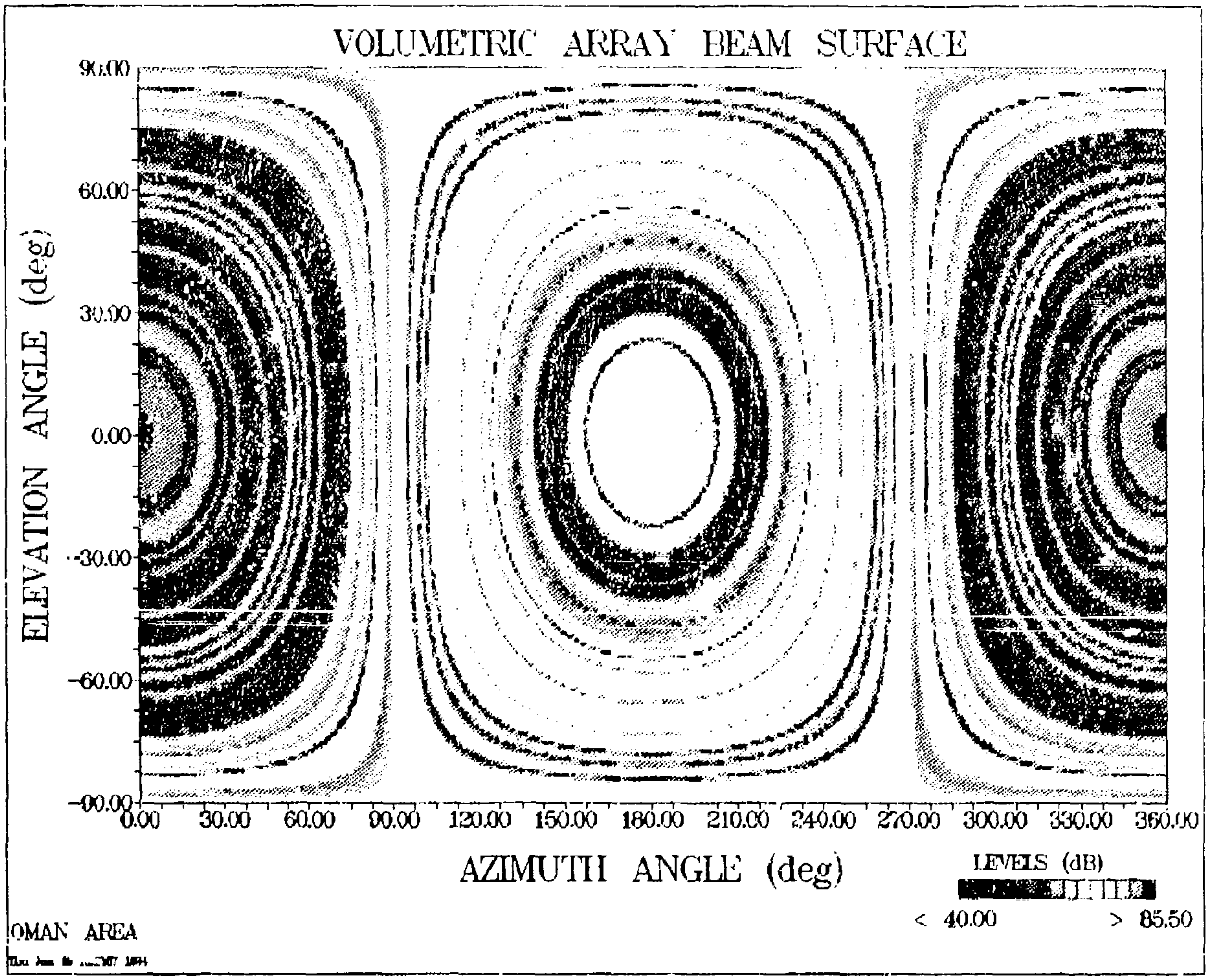


Figure 21: Example volumetric array beam surface display plot. The volumetric array beam surface was plotted by vol_beam_surf.x (section 7.16).

ACKNOWLEDGMENTS

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